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LUBRICATION HANDBOOK FOR USE IN THE SPACE INDUSTRY PART A - SOLID LUBRICANTS PART B - LIQUID LUBRICANTS

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16. ABSTRACT

This handbook is intended to provide a ready reference for many of the solid and liquid lubricants used in the space industry. Lubricants and lubricant properties are arranged systematically so that designers, engineers, and maintenance personnel in the space industry can conveniently locate data needed for their work.

The handbook is divided into two major parts (A and B). Part A is a compilation of solid lubricant suppliers information on chemical and physical property data of more than 250 solid lubricants, bonded solid lubricants, dispersions and composites. Part B is a compilation of chemical and physical property data of more than 250 liquid lubricants, greases, oils, compounds and fluids. The listed materials cover a broad spectrum, from manufacturing and ground support to hardware applications for missiles and spacecraft.

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Part A of the handbook is divided into six major sections and Part B into four sections. Section I, introduction, defines solid lubricants, outlines their advantages and disadvantages, states the purpose of Part A and gives a general description of the various types of solid lubricants; Section II contains alphabetical lists of manufacturers and products, solid lubricant classification, specifications materials, "LOX" and fuel compatibility, and usage tables for selected bonded solid lubricants and composite materials; Section III contains data sheets which give chemical and physical properties of selected lubricants; Section IV includes data sheets listing manufacturer supplied test and application data; Section V covers laboratory test data obtained at MRI on selected solid film lubricants, gear test data and composite materials; Section VI containing three appendices, one a glossary of terms, the second containing excerpts of solid lubricant specifications, and the third, description of test apparatus and procedures used in laboratory evaluation of solid lubricants.

The four sections of Part B are Section I, introduction, which states the purpose of Part B, gives instructions for use of the handbook, presents indexes of all materials included, and a series of charts illustrating various kinds of potential application; Section II includes brief written description of military specifications; Section III contains data sheets, listing physical and chemical properties of selected lubricants; and Section IV containing two appendices, one a glossary of lubrication terms, and the second a series of summaries of standard testing methods used to evaluate lubricating oils, gears, and fluids.

All units are given in the SI System except in areas where confusion exists in the use of the system.

FOREWORD

This handbook was prepared by the Engineering Sciences Division of Midwest Research Institute, Kansas City, Missouri, under Contract No. NAS8-27662, Control No. DCN-1-1-50-13616(IF), MRI Project No. 3535-E. The program is administered by the Engineering Physics Branch of the Materials Division of the Propulsion and Vehicle Engineering Laboratory, George C. Marshall Space Flight Center. Mr. Keith E. Demorest is the technical representative of the NASA Contracting Office.

The work on this handbook was under the technical supervision of Mr. Vern Hopkins, Assistant Director of the Engineering Sciences Division. Mr. Mahlon E. Campbell is the project leader. The collection and compilation of data and conversion of units to the SI System were carried out by Mr. Mahlon E. Campbell and Mr. Mason B. Thompson.

Approved for:

MIDWEST RESEARCH INSTITUTE

Harold L. Stout

Harold L. Stout, Director
Engineering Sciences Division

6 March 1972

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NOTICE

The inclusion or exclusion of any manufacturer's product in or from this handbook shall not be construed as either approval or disapproval of any product or manufacturer by the United States Government.

The information contained in this handbook was obtained primarily from government reports, military specifications, qualified products lists and suppliers of commercial lubricants.

The handbook will answer many questions that confront designers and other lubricant users; however, questions will arise which are outside the scope of the handbook. In addition, only a small percentage of the available lubricants are included in the handbook. Obviously, lubricants not given in the handbook can be found that will satisfy some of the same applications as those included herein. The chief advantage of the handbook is that it aids in matching a specific lubricant to a particular application.

TABLE OF CONTENTS

Page

PART A - SOLID LUBRICANTS

PART B - LIQUID LUBRICANTS

PART A - SOLID LUBRICANTS

AI - INTRODUCTION

Solid film lubricants can generally be defined as materials that provides lubrication to two relatively moving surfaces under essentially dry conditions. The most common, and still the most widely used, of the solid film lubricants, powdered graphite and molybdenum disulfide, have been known and used limitedly for more than 100 years. The development of these and other solid lubricants, as has also been the case of fluid lubricants and greases, has not been an exact science but an "art" or technology that has developed through many years of service experience. And, it has been only in the last 20 years that they have been recognized and accepted to any significant extent by industry due to need for lubricants that would meet temperature and other environmental conditions beyond the range of conventional fluid and synthetic lubricants.

Bonded solid film lubricants in which the lubricating solid film is attached to the substrate by a binder material is even more recent in development than the powdered solid films. In the early development of bonded films, a large variety of binder materials were evaluated including such materials as corn syrup, asphalt base varnish, silicone base varnish, and glycerol. Binder materials now include thermoplastic and thermosetting resins, metals, ceramics and metal salts. Lubricating solids now being investigated and developed include soft metals, metallic oxides, metallic sulfides and many others.

The study of solid lubricants, as they are now known, is a relatively new field of lubrication. No systematic study of these materials began until a considerable time after they were introduced in the aircraft industry (1940 to 1950). In their early applications, they were erronously sold as "cure-all" lubricants, resulting in misapplications. Unfortunately, these misapplications frequently outweighed the proper applications, thereby slowing down the general acceptance of these lubricants by industry. There are many areas of lubrication in which specific types of solid films can be used to advantage and there are also areas when they should not be used, as there is also no single solid film lubricant that will meet all requirements.

Many authors have discussed the applications and listed the various advantages and disadvantages of solid film lubricants, some of these are:

A. Advantages of Solid Lubricants

1. Do not collect grit.

2. Can be used under extremely high load conditions.

3. Excellent storage stability.

4. LOX and oxygen compatible (inorganically bonded films).

5. Suitable for use over wide temperature range.

6. Resistant to the effects of nuclear and gamma radiation.

7. No disposal problem.

8. Friction decreases with increase load.

9. In some applications solid films will provide lubrication for the life of the parts.

B. Disadvantages of Solid Lubricants

1. Limited amount of lubricant available.

2. Friction coefficient higher than with hydrodynamic lubrication.

3. Provisions for the effective removal of wear debris must be provided.

4. Considerations must be given to removing heat from contact zone of bearings and gears when using solid film lubricants.

5. More expensive (costly relubrication).

6. Avoidance of contamination during coating processes and assembly of parts lubricated with solid film lubricants.

7. Elevated temperature cure cycle of some solid films will damage the mechanical properties of some materials.

The selection of the proper solid film lubricant for a particular application is a complex problem for the lubricant engineer, involving a consideration of specific lubricant properties and operating parameters and environment of the equipment. A lengthy discussion of the theory of lubrication by solid materials, such as graphite and molybdenum disulfide, and others, is beyond the scope of this handbook. The material in this handbook is intended as a general aid or guide to the designers of spacecraft and ground support equipment in selection of solid film lubricants for specific applications. This book is not intended to supplant other publications or expert opinions on specific problems, such as corrosion protection, LOX, fuel, solvent and other material compatibility.

Users of this handbook are urged to contact the Materials Division of the Propulsion and Vehicle Engineering Laboratory, Marshall Space Flight Center, for aid in selecting solid lubricants for special applications.

The inclusion or exclusion of any manufacturer's product in or from this handbook shall not be construed as either approval or disapproval of any product or manufacturer by the United States Government.

The information contained in this handbook was obtained primarily from government reports, military and federal specifications, and from data sheets and product literature from suppliers and manufacturers of solid film lubricants. Some of the data are also based on tests conducted in the Institute laboratory.

This handbook will answer many of the problems confronting designers and users of solid film lubricants; however, questions will undoubtedly arise which are outside the scope of this handbook. In addition, only a representative portion of the numerous solid film lubricants are included in this handbook and there are, no doubt, other solid films not listed which will satisfy the same applications of some of these listed herein.

C. Description of Solid Film Lubricants

Solid film lubricants encompass many separate and distinct types and classes of lubricating materials, each having somewhat different properties, operating ranges, method of attachment to the substrate material, etc. These film lubricants could be grouped in many ways; one of the most logical, and the one used herein, is to classify them according to the manner by which they are attached to the substrate, since in many cases similar lubricating compounds are used in more than a single class of solid films.

Unbonded Solid Lubricants

The unbonded solid films, in granular or powdered form, are the simplest types of the solid film lubricants, and, although not physically or chemically attached to the substrate material, they do adhere to many substrate materials by mechanical or molecular action, and provide a low friction lubricated surface. In general, these film lubricants will have lower adhesion, wear-life, load carrying capacity, fluid resistance, and other properties than the bonded solid film lubricants. The most common of the unbonded lubricants are graphite and molybdenum disulfide, although other materials, such as: Teflon and other plastics, talc, and metallic salts are used in this form. The temperatures at which these lubricants may be used is determined by their reaction in air; molybdenum disulfide oxidizers at about 399°C (750°F) (molybdenum trioxide) and tends to reduce its lubricating properties. Graphite loses its absorbed water at elevated temperatures and is generally not recommended for temperatures above 538°C (1000°F). Some metallic salts also exhibit reasonably good lubricating properties at temperatures up to 568°C (1000°F); however, most unbonded film lubricants are limited to temperatures of 260°C (500°F) or lower.

Unbonded solid film may be applied by several methods depending on the type or form in which it is applied. In the dry powder condition, it may be applied by brushing, dipping, spraying or burnishing. In a fluid suspension or colloidal form (water or solvent), it may be applied by the brush, dip, or spray method, allowing the nonadhesive carrier to evaporate. In aerosol containers (gas carrier, i.e., Freon), the powdered dry film may be sprayed directly on the lubricated surface. In both the latter forms the fluid or gas carrier does not improve the adhesion or lubricating properties of the film, but only provides a convenient form of application.

Resin-Bonded Solid Lubricants

Resin-bonded films are currently the most widely used solid lubricant. This group includes both air-cured and heat-cured materials (air-cured and heat-cured refer to the methods used in polymerizing the resin binder). The solid lubricant pigments used most frequently in resin-bonded films are: molybdenum disulfide (MoS_2), tungsten disulfide (WS_2), polytetrafluoroethylene (PTFE), and graphite.

The pigment may be one lubricating solid or a mixture of several. The function of the pigment is to provide the wear reduction and low friction required for the system being lubricated. The binder serves to hold the lubricating pigment to the metal surface so that the motion of parts does not result in the complete loss of the pigment from the system. In the formulation of resin-bonded solid lubricants, the proper pigment-to-binder ratio is very important. However, the pigment-to-binder ratio can vary widely with the particular resin used.

There are certain factors that can affect the overall performance of bonded films in any given situation. One is the condition of the metal surfaces being lubricated. In most cases the surface is changed or modified by some pretreatment to obtain optimum film performance. Other factors involve the variables directly related to the application of the film, such as spraying techniques. In addition to application factors, environmental conditions and the operating characteristics of the system being lubricated can drastically affect the film. These factors should be considered in any final selection of a bonded solid lubricant.

The resin-bonded solid lubricants are generally applied in thin films to the surfaces of the components being lubricated. In most cases the surfaces have been pretreated in a manner that will depend on the substrate being used and the service for which the parts are intended. The resin-bonded solid lubricant films can be applied by spray, dip, or brush methods. Spray application is usually the most satisfactory. Spray coating thickness should range from 5×10^{-6} to 2×10^{-5} m. (0.0002 to 0.0008 in.), the optimum being about 1.27×10^{-5} m. (0.0005 in.). If the film is too thick, it will be structurally weak and peel or flake off with sliding motion under load; on the other hand, a film that is too thin may result in premature failure due to rupture. Although some test results are contradictory, it appears that for high load a thinner film (7.6×10^{-6} m. (0.0003 in.) per surface will give the longest wear-life. For lighter load conditions the thickness can be substantially increased. However, economics of the coating process (spray time, curing time, etc.) should enter into any decision involving the use of thicker films. A second area that must be considered if thick films are used is wear debris generation. Large amounts of wear debris are generated from thick films and some provision must be made for the removal of this debris from the bearing area.

The wear behavior and wear-life characteristics of a resin-bonded solid lubricant are different from those of most other solid film lubricants. In its initial wear-in, it will exhibit relatively high wear which will become less with time. The initial high wear rate can be attributed to the loss of loose material from the surface of the film and the compaction of the film by the applied load. As running continues, the film will appear glossy or burnished. The best performance, lowest wear and steadiest friction, are obtained during this time.

Bonded dry film lubricants can provide long wear-life, good abrasion resistance, good adhesion, and good resistance to a variety of solvents. Performance of the films depends to a large extent on the cured properties of the binders used.

Air-Cured Resin-Bonded Solid Lubricants

An air-cured resin-bonded solid lubricant consists of a lubricating powder, or powders, in an air-curing resin binder material. The lubricating pigments most frequently used are molybdenum disulfide, graphite, or a lubricating plastic such as polytetrafluoroethylene. This type of solid film lubricant usually contains a lower total solid content than heat-cured film to provide a more satisfactory solution for aerosol application.

Binder materials used in the air-drying solid lubricants are thermoplastic resins such as cellulosics, and acrylics. These resins require no heat cure and therefore can be used on substrates that cannot be baked. They produce a fairly hard film, but do not have good resistance to solvents.

Heat-Cured Resin-Bonded Solid Lubricants

Heat-cured, resin-bonded solid lubricants are the most widely used in the dry film lubricant industry. The materials consist of the lubricating pigment and a specially formulated resin binder. The lubricating pigment is usually a mixture of approximately 90% molybdenum disulfide and 10% graphite, which seems to give the best results when friction and wear are considered. The relatively small concentration of graphite appears to improve the low load performance (lower friction) of the MoS_2. Replacing graphite with antimony trioxide (Sb_2O_3) produces the same effect. Films are available that contain small percentages of silver, indium, lead, and so forth, as well as a mixture of MoS_2 and graphite, but the lubricant coatings containing only graphite and molybdenum disulfide are more readily available.

Curing of the binders in these films will usually require a bake of approximately 1 hr. at 149°C to 204°C (300°F to 400°F). Special films such as those containing polyimide binders require baking temperatures of 302°C (575°F) for 2 hr. Because of the baking temperature, care in the selection of the metal substrate is required. Temperatures of about 135°C (275°F) for 1 hr. can weaken certain aluminum alloys.

Binders that are normally used in the heat-cured solid lubricants are thermosetting and include alkyds, phenolics, epoxides, silicones, polyimides, and polyphenylene sulfide (PPS). Alkyds are relatively inexpensive, cure at low temperatures and are generally easy to handle. Phenolics have good surface adhesion and are harder than the alkyds, but require a high-temperature curing cycle, usually 149°C to 204°C (300°F to 400°F) for 1 hr. Epoxy resins have excellent solvent resistance and very good adhesion, but are softer than phenolics. Modified epoxyphenolics combine the good properties of both materials. Silicones offer a higher operating temperature, but are softer and have only fair adhesion. Normally, they are used only for high-temperature service and then only when the brittleness of the silicate type of binder presents a problem.

The polyimides are relatively new in the adhesive field. They were originally intended as laminating resins for use with fiber glass cloth. They have also been used as a wire insulation in electric motors where high temperature is a problem. The polyimide binder materials have extended the useful range of the resin-bonded lubricant films up to approximately 371°C (700°F). Films containing these materials have been evaluated at temperatures up to 538°C (1000°F) in vacuum. Such tests have demonstrated that the polyimide resins do have a limited life at extreme temperatures.

The polyimide bonded solid-lubricant films have also demonstrated their superiority in extremely high load application.

There are several other new binder materials being considered for use with solid lubricants. These materials are similar in structure to the polyimides and include the pyrones, PBI (polybenzimidazole), PBT (polybenzothiazole), and polyphenylene sulfide. Of these four materials, the pyrones are very resistant to oxygen and strong acids.

These heat-cured materials are superior to the air-drying materials and should be used where high load-carrying ability or long life is required. They are usable over the temperature range of -73°C to 371°C (-100°F to +700°F).

The importance of the resin-bonded solid lubricants has grown rapidly over the past 20 years. Because of this rapid growth, means of controlling the quality of the bonded films was needed. To insure that quality be maintained, government agencies have prepared specifications covering the materials and their uses. Typical of these specifications are MIL-L-8937, MIL-L-23398, and MIL-L-46010. There are also several custom variations available in these heat-cured solid film lubricants.

Inorganic-Bonded Solid Film Lubricants

Inorganic-bonded lubricating pigments are usually referred to as high-temperature solid lubricants. These materials are intended for use at temperatures from approximately 260°C (500°F) to in excess of 649°C (1200°F). There is considerable overlap in applicable temperature ranges for the various binder materials; however, certain ones operate very satisfactorily at temperatures down to 149°C (300°F). The high-temperature inorganic-bonded solid lubricants are a logical extension to the resin-bonded types. They employ ceramic or salt-based binders to give greater temperature resistance than resins and usually employ lubricating solids which are more thermally and oxidatively stable than graphite or MoS_2. Solid lubricants of this type usually contain lubricating solids (pigments) such as lead oxide, lead sulfide, calcium fluoride, gold, silver, and so forth. There are exceptions, however, and a number of the ceramic and salt-based binders are used with MoS_2 and graphite.

Nonceramic (Silicate, Phosphate)

The bonding technique for these materials commonly employs water-soluble silicates, phosphates, etc., which produce a hard coating that tends to be brittle when cured (curing is accomplished by slowly driving out the excess water by heating). In general, they can be used at temperatures from -73°C to 538°C (-100°F to +1000°F). Solid lubricants containing the salt-based binders usually contain graphite, MoS_2, lead sulfide, powdered metals, etc. They can be used in extremely high load areas, with loads in excess of 6.895×10^8 N/m^2 (100,000 psi). However, for applications where movement is a prime design consideration, they are not as good as resin-bonded films as far as wear-life and strength are concerned. Two advantages of these films over others are that (1) they will not outgas significantly in a vacuum of 10^{-9} torr, and (2) they are compatible with liquid oxygen. However, there are disadvantages such as (1) lack of corrosion protection, and (2) softening of the film in the presence of water or moisture for extended periods of time.

Ceramic-Bonded

The ceramic bonding agents are glasses rather than resins, and soften when heated. On cooling they solidify and serve as a bonding agent for the dispersed lubricant. Their principal advantage is their good strength at elevated temperatures. The lubricating solids commonly employed with ceramic binders are graphite, calcium fluoride (CaF_2), lead oxide, and mixture of barium fluoride (BaF_2) and CaF_2. Useful temperature ranges are from approximately 260°C (500°F) to more than 816°C (1500°F).

Although the ceramic-bonded materials, as a class, do not perform as well (i.e., have low friction and wear) as the resin-bonded materials at lower (room) temperatures, they generally exceed the resin-bonded films' capabilities by a considerable amount (over 10 times) at higher temperature 371°C (700°F). There are exceptions, however, one being when the lubricants are run at high speeds which result in high temperatures over 371°C (700°F) being generated in the contact zone. In such cases, the ceramic-bonded films will generally outperform the resinous films.

One problem in the use of ceramic-bonded materials is the thermal expansion of the cured coating. This must be matched closely with the expansion of the base material. If the thermal expansion characteristics are not the same or very similar, the coating will be fractured and be easily removed from the substrate.

D. Pretreatment for Solid Films

Pretreatment of the substrate material prior to the application of any bonded solid film lubricant can greatly affect its performance; in most cases, it improves the wear-life and other properties of solid films and, in many cases, it is a prerequisite for satisfactory adhesion and optimum lubricant properties. The type of substrate pretreatment recommended is dependent on several factors; including the specific substrate material, the bonding resin employed, and the operating environment of the film application. However, in general, pretreatments of the substrate are grouped into one of two classes: cleaning to remove dirt, grease, oil, surface scale, etc.; and surface treatment by chemical or mechanical means to improve the surface for better mechanical bond of the resin. The chemical films provide corrosion resistance and a surface to which the bonding resin will adhere better than to the substrate.

Cleaning of the substrate is usually by means of sanding, scraping, grit or sand blasting to remove dirt, scale and foreign material, and a solvent, acid or other chemical rinse to remove any surface oils. A clean surface free of any oil film is essential for good bonding and adhesion of any adhesive or resin bond. Substrate-treated films to improve corrosion resistance and improve resin bond include phosphating, sulfiding, anodizing, chemical, etc.

The chemical pretreatments mentioned above are used primarily in conjunction with the resin-bonded solid lubricants that have curing temperatures below 204°C (400°F). These same pretreatments can be used with the inorganic-nonceramic-bonded lubricants if the curing temperatures can be held below 204°C (400°F). The most accepted surface pretreatments for the inorganic-bonded films are the vapor or grit blast. Pretreatment of surfaces for ceramic-bonded solid lubricants is, in nearly all cases, grit blasting.

E. Application Processes

The processes by which the bonded solid lubricants are applied to bearing surfaces can have considerable effect on the film behavior and performance. All of the various types of bonded film (resin, inorganic nonceramic, and ceramic bonded) can be applied by spraying, dipping, or brushing.

Of the three common methods, spraying and dipping are most often used. However, there certainly are cases where brushing can be used to advantage. The commonly held opinion that "spraying a dry lubricant is just like spraying paint," is not correct. A dry lubricant is a very special material and should be treated as such. Applying a solid lubricant in the sloppy manner often used in spray painting will result in a very degraded film. In a dipping process, the entire part is usually completely immersed in a lubricant bath. Sometimes the dip process will produce a film of nonuniform thickness.

Sputtering

Film applied by the conventional methods mentioned above have film thicknesses greater than 2.54×10^{-6} m. (0.0001 in.) per surface. In many specialized applications, such as close tolerance ball bearings, the aforementioned film thickness is too great and can cause interference and jamming of the bearing with wear debris. For the application where thin films are required because of close tolerances, the application of lubricants by the sputtering technique appears to have the most promise.

Sputtering of materials is not new; the process used has been in use for over 100 years. However, the application of solid lubricant materials to surfaces by the sputtering process is relatively new.

Sputtering is generally performed in an inert gas atmosphere (argon, Xenon, etc.) of several microns pressure. A potential is applied across the electrodes to ionize the inert gas. The material to be sputtered is the cathode (target). The sputtered material from the target is ejected through the plasma and deposits on the part being coated. The basic mechanism of sputtering is thus a process where the positive ions of the inert gas, which forms a gaseous plasma, are accelerated through an electron free region with enough energy to knock off or sputter the negatively charged target material. The sputtered material is deposited on the work piece substrate, which is placed close to the target source. Lubricant film thicknesses of from 2×10^{-7} m. to 1×10^{-6} m. (2,000 to 10,000 A) can be applied by the sputtering process.

The most frequently used sputtering systems are powered by either DC or RF power supplies. Sputtered film of MoS_2 lubricant has been successfully applied to journal bearings, spur gears, ball bearings, and many other parts requiring lubrication.

Personnel at the NASA-Lewis Research Center have conducted extensive studies in the area of sputtered lubricants. Their outstanding work in this field has resulted in the widespread interest now being shown in the sputtering process.

There is only one sputtered lubricant film identified by number in this document. It is identified as MEL-1 and is available from Midwest Research Institute. The MEL-1 film contains only molybdenum disulfide. However, other materials such as CaF_2, BaF_2, and mixtures of these high temperature solid lubricants have been successfully applied by the sputtering process.

AII - INDICES OF MANUFACTURERS AND PRODUCTS

USAGE TABLES - SELECTED SOLID LUBRICANTS AND COMPOSITES

ALPHABETICAL LIST OF SOLID FILM AND COMPOSITE LUBRICANT MANUFACTURERS

	Page Nos. Sections AII	AIII	AIV	AV
Acheson Colloids Company Port Huron, Michigan	3	1,2	1-4	
Allegheny Plastics, Inc. Coraopolis, Pennsylvania				20
Ball Brothers Research Corporation Boulder, Colorado	3	3	5	
The Barden Corporation Danbury, Connecticut				20
Bel-Ray Company, Inc. Farmingdale, New Jersey	3	4	7	
Bemol Corporation Newton, Massachusetts				19
Cerac, Inc. Butler, Wisconsin	3	5,6		
Dixon Corporation Bristol, Rhode Island				19,20
Dow Corning Corporation Midland, Michigan	3,4	7,8	9,11	
Drilube Company Glendale, California	4	9,10	13,14	
Dri-Slide, Inc. Fremont, Michigan	4	11	15	
E. I. du Pont de Nemours and Company, Inc. Wilmington, Delaware				19,20,21
Electrofilm Corporation North Hollywood, California	4	13,14	17-20	

	Page Nos. Sections AII	AIII	AIV	AV
Everlube Corporation North Hollywood, California	5	15,16	21,22	
Fel-Pro, Inc. Skokie, Illinois	5	17	23	
General Magnaplate Corporation Belleville, New Jersey	5	19,20	25,26	
H. A. Henderson Company Los Angeles, California	5	21	27	
Hohman Plating and Manufacturing, Inc. Dayton, Ohio	5	23,24	29,30	
Lubeco, Inc. Compton, California	6	25	31	
Microseal Corporation Mountain Vew, California	6	27	33	
Midwest Research Institute Kansas City, Missouri	6	29	35,36	
National Process Industries South Gate, California	6	31	37,38	
Phillips Petroleum Company Bartlesville, Oklahoma				21
Poxylube, Inc. Indianapolis, Indiana	6	33	39	
Product Techniques, Inc. Hawthorne, California	6	35	41,42	
Pure Carbon Company, Inc. St. Marys, Pennsylvania				21
Rogers Corporation Rogers, Connecticut				20
Sandstrom Products Company Port Byron, Illinois	6	37	43	

SOLID LUBRICANT PRODUCT LIST

Manufacturer and Lubricants	Page Nos. Sections AIII	AIV
Acheson Colloids Company	1	1
Release Coating No. 7		1
DAG 154	1	1
DAG 244	1	1
DAG 250	1	1
Molydag 254	1	3
Emralon 310	1	3
Emralon 311	1	3
Emralon 312	1	3
Emralon 315	2	3
Emralon 317	2	2
Emralon 319	2	2
Emralon 320	2	2
Emralon 321	2	2
Emralon 327	2	2
Emralon 328	2	4
Emralon 329	2	4
Emralon 330	2	4
Ball Brothers Research Corporation	3	5
VAC KOTE BPS 18.07	3	5
VAC KOTE 21207	3	5
Bel-Ray Company, Inc.	4	7
Molylube AR	4	7
Molylube SR	4	7
Molylube N	4	7
Molylube Spraycote	4	7
Cerac, Inc.	5	
Lubricant Powders	5	
SP-111	6	
Dow Corning Corporation	7	9
Molykote 106	7	11
Molykote X-15	7	11
Molykote M-88	7	11
Molykote Spraykote	7	11
Molykote 321	7	10
Molykote 523	7	10
Molykote M-8800	7	10
Molykote 273	8	11
Molykote 557		9

SOLID LUBRICANT CLASSIFICATION

	Lubricant Name or Code	Page Nos. Sections AIII	AIV
I. Unbonded			
	DAG 154	1	1
	VAC KOTE 21207	3	5
	Cerac Powdered Materials	5	
	MoS_2 - Molykote Type Z		
	MoS_2 - Molykote Microsize		
	MoS_2 - Electro-Moly	14	18
	Graphite - Electro-Graph	14	18
II. Organic-Bonded Films			
A. Air-Dry Films			
	Emralon 320	2	2
	Emralon 321	2	2
	Emralon 322	2	2
	Emralon 327	2	2
	Emralon 328	2	4
	Emralon 329	2	4
	Molylube AR	4	7
	Dow Corning 3402	8	9
	Dow Corning 1-3943	8	9
	Dow Corning 1-3944		9
	Molykote 321	7	10
	Molykote 523	7	10
	Molykote M-8800	7	10
	Molykote M-88	7	11
	Lubri-Bond M	14	18
	Lubri-Bond N	14	18
	Lubri-Bond A	14	19
	Lubri-Bond HT	14	20
	Fel-Pro C-300	17	23
	Magnalube D-5261	19	26
	Surfkote A-2178A	24	29
	Surfkote 1625A	23	30
	Polylube 420	33	39
	Techlube PT-26M	35	41
	Sandstrom 26A	37	43

SPECIFICATION SOLID LUBRICANTS

Specification	Lubricant Name or Code	Manufacturer or Suppliers
MIL-M-7866	Powdered Molybdenum Disulfide (MoS_2)	Climax Dow Corning Corporation Electrofilm, Inc. Product Techniques, Inc.
MIL-G-6711	Graphite	Electrofilm, Inc. Dixon
MIL-L-8937	Molylube SR	Bel-Ray Company, Inc.
	Molykote 106	Dow Corning Corporation
	Drilube 1A	Drilube Company
	Lube-Lok 5396	Electrofilm, Inc.
	Fel-Pro C640	Fel-Pro, Inc.
	Henderlube 402A	H. A. Henderson Company
	Surfkote M1284	Hohman Plating, Inc.
	Microseal 200-1	Microseal Corporation
	NPI-14	National Process Industries
	Poxylube 500	Poxylube, Inc.
	Everlube 620	Everlube Corporation
MIL-L-23398	Dow Corning 3402	Dow Corning Corporation
	Lubri-Bond A	Electrofilm, Inc.
	Surfkote A-1625	Hohman Plating & Manufacturing, Inc.
MIL-L-46010	Ecoalube 642	Everlube Corporation
	Fel-Pro C-651	Fel-Pro, Inc.
	Henderlube 413	H. A. Henderson Company
	Surfkote M-2049	Hohman Plating & Manufacturing, Inc.
	Sandstrom 9A	Sandstrom Products Company
MIL-L-81329	Molylube N	Bel-Ray Company, Inc.
	Molykote X-15	Dow Corning Corporation
	Everlube 811	Everlube Corporation
	Lube-Lok 2306	Electrofilm, Inc.
NASA-1367	Lube-Lok 2306	Electrofilm, Inc.
NASA-A-D-66A	Lube-Lok 4306	Electrofilm, Inc.
05-10626-A (USN/BW)	Microseal 100-1	Microseal Corporation
MSFC 502	MLF-5	Midwest Research Institute
	NPI-5	National Process Industries
MSFC 253	MLF-9	Midwest Research Institute
NASA 50M60434	MLR-2	Midwest Research Institute
	NPI-425	National Process Industries
MIL-L-46147	Sandstrom 26A	Sandstrom Products Company

SOLID FILM LUBRICANT "LOX" AND ROCKET FUEL COMPATIBILITY

Product Name or Code	Compatibility Rating: "LOX" *	Compatibility Rating: Rocket Fuels **	Manufacturer	Reference
DAG 154	Batch Test	-	Acheson Colloids Company	*, a/
Molykote Spray	Batch Test	-	Dow Corning Corporation c/	*, a/
Molykote X-15	Batch Test	Batch Test	Dow Corning Corporation	*, a/, **, b/
Molykote Z	Satisfactory	-	Dow Corning Corporation	*, a/
Molykote 321	Satisfactory	Satisfactory	Dow Corning Corporation	*, b/, **, b/
Molylube AR	No Reaction	-	Bel-Ray Company, Inc.	*, b/
Molylube N	No Reaction	-	Bel-Ray Company, Inc.	*, b/
Molylube Spray	Batch Test	No Reaction	Bel-Ray Company, Inc.	*, a/, **, b/
CL-5940	Batch Test	-	CBS Laboratories	*, a/
CLD-5940	Satisfactory	-	CBS Laboratories	*, a/
Drilube 701	Batch Test	-	Drilube Company, Inc.	*, a/, **, b/
Drilube 702	Satisfactory	-	Drilube Company, Inc.	*, a/, **, b/
Drilube 805	No Reaction	-	Drilube Company, Inc.	*, b/, **, b/
Drilube 831	No Reaction	No Reaction	Drilube Company, Inc.	*, b/, **, b/
Drilube 842	No Reaction	No Reaction	Drilube Company, Inc.	*, b/, **, b/
Drilube 861	No Reaction	-	Drilube Company, Inc.	*, b/, **, b/
Drilube 867	No Reaction	-	Drilube Company, Inc.	*, b/, **, b/
Drilube 868	No Reaction	-	Drilube Company, Inc.	*, b/, **, b/
Drilube 869	No Reaction	-	Drilube Company, Inc.	*, b/, **, b/
Drilube 870	No Reaction	-	Drilube Company, Inc.	*, b/, **, b/
Drilube 898	No Reaction	-	Drilube Company, Inc.	*, b/, **, b/
Electrofilm 66-C	Batch Test	-	Electrofilm Corporation	*, a/
Electrofilm 2306	No Reaction	-	Electrofilm Corporation	*, b/
Electrofilm 2396	Batch Test	-	Electrofilm Corporation	*, a/
Electrofilm 2406	No Reaction	No Reaction	Electrofilm Corporation	*, b/, **, b/
Electrofilm 2606	No Reaction	-	Electrofilm Corporation	*, b/
Electrofilm 2696	No Reaction	-	Electrofilm Corporation	*, b/
Electrofilm "M"	No Reaction	-	Electrofilm Corporation	*, b/

Product Name or Code	Compatibility Rating "LOX" *	Compatibility Rating Rocket Fuels **	Manufacturer	Reference
Inlox 44	No Reaction	No Reaction	Everlube Corporation	*, b/, **, b/
Everlube 811-B	Batch Test	No Reaction	Everlube Corporation	*, a/
Everlube 811	Batch Test	No Reaction	Everlube Corporation	*, a/
Everlube 812	No Reaction	No Reaction	Everlube Corporation	*, b/
Surfkote LO-1800	No Reaction	-	Hohman Plating & Manufacturing, Inc.	*, b/
Lubeco 905	No Reaction	-	Lubeco, Inc.	b/
Sodium Silicate and Graphite	Batch Test	-	Materials Division, P&VE Laboratory, Marshall Space Flight Center	*, a/
Sodium Silicate and Talc	Batch Test	-	Materials Division, P&VE Laboratory, Marshall Space Flight Center	*, a/
Microseal 100-1	No Reaction	-	Microseal Corporation	*, b/
Microseal 200-1	No Reaction	-	Microseal Corporation	*, b/
Microseal 300-1	No Reaction	-	Microseal Corporation	*, b/
MLF-5	Satisfactory	-	Midwest Research Institute	
MLF-9	Satisfactory	-	Midwest Research Institute	*, a/
RIA-9A	No Reaction	No Reaction	Sandstrom Products Company	*, b/, **, b/

a/ NASA TM X-985, "Compatibility of Materials with Liquid Oxygen," August 1964.
b/ Manufacturer's literature or test reports.
c/ Manufactured and distributed by Alpha-Molykote Division of the Dow Corning Corporation.

NOTES: No Reaction - This notation identifies that the material does not react in the presence of "LOX" or rocket fuels, but has not been submitted to or will not pass the "ABMA" Impact Tester Requirements.

- \- Not recommended for usage, or no information available.
- * "LOX" compatibility.
- ** Rocket fuels compatibility.

USAGE TABLE - SELECTED SOLID LUBRICANTS AND COMPOSITES

Film Material Designation	Types of Applications: Bearings: Ball	Bearings: Roller	Bearings: Journal	Gears	Sliding Surfaces	Threaded Fasteners	Metal-working	Use Conditions: Load	Speed	Vacuum Out-gassing	Temperature	Corrosion Resistance: Fretting	Corrosion Resistance: Environmental	Ref. Pages Sections: AIII	Ref. Pages Sections: AIV
AFSL-28 (MRIONITE)	X		X		X	X		Medium to High	Low to High	Z	427° to 870°C	X		29,31	36,38
AFSL-29			X		X	X		Medium to High	Low to High	Z	260° to 649°C	X		29	36
AFSL-41	X	X	X		X	X	X	Low to High	Low to Medium	Z	RT to 370°C	X		8,14, 24	9,20, 43
DOW CORNING 3402	X	X	X		X	X	X	Low to High	Low to Medium	Z	RT to 204°C	X	X	8	9
DRILUBE No. 1a/	X	X	X		X	X	X	Low to High	Low to Medium	Z	-54° to 204°C	X		9	14
DRILUBE 702					X	X		Low	Low	Z	RT to 204°C	X		10	14
EVERLUBE 620a/	X	X	X		X	X	X	Low to High	Low to Medium	Z	RT to 204°C	X	X	15	21
EVERLUBE 811b/	X	X	X		X	X	X	Low to High	Low to Medium	Z	-100° to 538°C	X		15	21
FEL-PRO C-200	X	X	X	A	X	X		Low to High	Low to High	OK	-54° to 649°C	X		17	23
FEL-PRO C-300	X	X	X	A	X	X		Low to Medium	Low to Medium	OK	-54° to 538°C	X		17	23
INLOX 44					X	X		Low	Low	Z	-54° to 204°C	X	X	16	21

USAGE TABLE - SELECTED SOLID LUBRICANTS AND COMPOSITES

Film Material Designation	Types of Applications							Use Conditions						Ref. Pages Sections	
	Bearings			Gears	Sliding Surfaces	Threaded Fasteners	Metal-working	Load	Speed	Vacuum Out-gassing	Temperature	Corrosion Resistance			
	Ball	Roller	Journal									Fretting	Environmental	AIII	AIV
LUBECO 905	X	X	X	A	X	X		High	Low to Medium	OK	-100° to 538°C	X		25	31
LUBE-LOK 5396[a]	X	X	X		X	X	X	Low to High	Low to Medium	Z	-100° to 204°C	X		14	19
LUBE-LOK 5306[a]	X	X	X		X	X	X	Low to High	Low to Medium	Z	-100° to 204°C	X	X	14	19
LUBE-LOK 4396	X	X	X		X	X		Low to High	Low to High	Z	-54° to 204°C	X	X	14	19
LUBE-LOK 66C					X	X		Low to Medium	Low to Medium	Z	-100° to 204°C	X		13	17
LUBE-LOK 2006		X	X		X	X		Low	Low	Z	-100° to 370°C	X		13	17
LUBRI-BOND A[c]	X	X	X		X	X		Low to High	Low to Medium	Z	-100° to 204°C	X		14	19
LUBRI-BOND N	Solid Film Lubricant of Niobium Diselenide for Use Where Electrical Conductivity is Required													14	18
LUBRI-BOND M	Touch-Up Film for Repair of Damaged Films													14	18
MICROSEAL 100-1[e]	X	X	X	A	X	X		Low	Low	OK	-100° to 538°C	X		27	33
MICROSEAL 200-1[e]	X	X	X		X	X		Low	Low	OK	-100° to 370°C	X		27	33
MEL-1	X	Sputtered MoS_2 Film						Low	Low to Medium	Z	-54° to 204°C			29	36

USAGE TABLE - SELECTED SOLID LUBRICANTS AND COMPOSITES

Film Material Designation	Types of Applications							Use Conditions						Ref. Pages Sections	
	Bearings			Gears	Sliding Surfaces	Threaded Fasteners	Metal-working	Load	Speed	Vacuum Out-gassing	Temperature	Corrosion Resistance			
	Ball	Roller	Journal									Fretting	Environmental	AIII	AIV
MLF-5	X	X	X	A	X	X	X	Low to High	Low to Medium	OK	-100° to 538°C	X		29	35,37
MLF-9	X	X	X	A	X	X	X	Low to High	Low to Medium	OK	-100° to 538°C	X		29	35
MLR-2 NPI 425 VAC KOTE 18.07			X	A	X	X	X	Low to High	Low to Medium	OK	-100° to 370°C	X	X	29,30 3	35,37, 5
MOLYKOTE 106[a]	X	X	X		X	X		High	Low to High	Z	-54° to 204°C	X	X	7	11
MOLYKOTE X-15[b]	X	X	X		X	X		Medium	Low to Medium	Z	-100° to 538°C	X		7	11
MOLYKOTE 321	X	X	X		X	X		Medium	Low	OK	-54° to 204°C	X		7	10
NPI 14[a]	X	X	X		X	X	X	Low to High	Low to Medium	Z	-54° to 204°C	X	X	31	37
NPI 1220 (VITROLUBE)			X		X	X		Low to High	Low to High	Z	RT to 427°C	X		31	38
RIA No. 9[d]			X		X	X		Medium	Medium	Z	-54° to 204°C	X	X	37	43
SURFKOTE M 1284[a]	X	X	X		X	X	X	High	Medium	Z	-100° to 300°C	X		23	30
SURFKOTE 1625[c]	X	X	X		X	X		Medium	Medium	Z	-54° to 204°C	X		23	30

USAGE TABLE - SELECTED SOLID LUBRICANTS AND COMPOSITES

Film Material Designation	Types of Applications							Use Conditions						Ref. Pages Sections	
	Bearings			Gears	Sliding Surfaces	Threaded Fasteners	Metal-working	Load	Speed	Vacuum Out-gassing	Temperature	Corrosion Resistance			
	Ball	Roller	Journal									Fretting	Environmental	AIII	AIV
SURFKOTE 2049 d/			X		X	X		Medium	Medium	Z	-54° to 204°C	X	X	23	29
VACKOTE 21207	X			A	X	X		Low to High	Low to Medium	OK	-268° to 149°C	X		3	5
Composite Material Designation														Section AV	
BARTEMP	X	Primarily Used as Crowned Bearing Retainer Material												19	
DUROID 5813	X		X	Primarily Used as Retainer Material in Ball Bearings										19	
DUROID 4300	X		X	Primarily Used as Retainer Material in Ball Bearings										19	
MOLALLOY PM 101	X			Primarily Used as Retainer Material in Ball Bearings										20	
MOLALLOY PM 103	X		X	High Load Bearings										20	
MOLALLOY PM 105	Electrical Brush Material													20	
SALOX M	X	Primarily Used as Retainer Material in Ball Bearings												19	

a/ MIL-L-8937 like material.
b/ MIL-L-81329 like material.
c/ MIL-L-23398 like material.
d/ MIL-L-46010 like material.
e/ Extremely thin films of doubtful value in high load applications.

NOTES: A = Has been evaluated on gears for certain space applications.
X - Satisfactory.
Z = Not listed in NASA 50M02442, Revision U, 1 March 1971.

AIII - GENERAL DESCRIPTION OF COMMERCIAL SOLID LUBRICANTS

ACHESON COLLOIDS COMPANY				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
DAG® 154	Colloidal graphite, isopropyl alcohol	Electrically conductive-printed circuits, static bleeds, etc. Lube for business machines, gaskets, mechanisms, rubber components, etc.	Not LOX or rocket fuels. Limited fluids and solvents.	Liquid, 20% solids, density; 888 kg/m^3 (7.5 lb/gal), diluent, alcohol, esters, and ketones.
DAG® 244	MoS_2 additives, resin binder	Dry film for sliding surfaces, aircraft fasteners, brake screw assemblies, vending machine components, etc. Good corrosion resistance meets load and endurance requirements MIL-L-8937.	Not LOX or rocket fuels, but some fluids and solvents.	Thick fluid; density, 1,284 kg/m^3(10.7 lb/gal), diluent; methanol, ethanol or butanol, but ACHESON extender is recommended. Cure at 149°C (300°F) for 1.0 hr.
DAG® 250	MoS_2 graphite, phenolic resin	Corrosion resistance and moderate load capacity.	Not LOX or rocket fuels.	Liquid; 42% solid, density = 1,092 kg/m^3 (9.1 lb/gal), cure temperature 149°C (300°F), 1 hr.
MOLYDAG® 254	MoS_2/lube pigments, thermoset resin	Bearing surfaces, sliding, rubbing or turning. Meets load and endurance requirements of MIL-L-8937.	Not LOX or rocket fuels, but many hydrocarbon fluids and solvents.	Good wear-life and corrosion properties. Service temperature 135°C (275°F), maximum 149°C (300°F), 55% solid. Density; 1,296 kg/m^3 (10.8 lb/gal); friction coefficients 123.
EMRALON® 310	PTFE coating phenolic resin	Dry film lubricant for material requiring low temperature cure. Has good adhesion, corrosion resistance, and release properties.	Not LOX or rocket fuels. Moderate resistance to chemicals and solvents.	Liquid density; 984 kg/m^3 (8.2 lb/gal). Cure at 149°C (300°F), 1.0 hr., service temperature 177°C (350°F), maximum 204°C (400°F).
EMRALON® 311	PTFE coating phenolic resin	Dry film for food handling and processing equipment. Properties similar to EMRALON® 310.	See EMRALON® 310.	Same as EMRALON® 310.
EMRALON® 312	PTFE coating acrylic resin	Dry film has low friction, good adhesion and release. May be used on most materials including flexible substrates, "O"-rings, seals, etc.	Moderate resistance to chemicals, solvents, and gasoline.	Liquid density; 1,068 kg/m^3 (8.9 lb/gal). Cure at 149°C (300°F), 30 min. Service temperature 149°C (360°F), maximum 177°C (350°F).

ACHESON COLLOIDS COMPANY				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
EMRALON® 315	PTFE coating epoxy resin	Dry film for uses requiring improved corrosion and chemical resistance. Good adhesion and heat stable.	Resist most solvents, organic and inorganic.	Liquid density; 984 kg/m^3 (8.2 lb/gal). Cure at 177°C (350°F) 1.0 hr. Service temperature 177°C (350°F), maximum 204°C (400°F).
EMRALON® 317	PTFE coating polyurethane resin	Dry film has low friction, good adhesion and corrosion resistance. Easily applied to most materials, wood, glass, plastic, rubber, etc.	-	Liquid density; 864 kg/m^3 (7.2 lb/gal). Air-dry in 5 to 6 hr. May be cured at 93°C (200°F) in 30 min. Service temperature 121°C (250°F), maximum 149°C (300°F).
EMRALON® 319	PTFE coating, silicone resin	Low friction film having high heat resistance and good release properties. Applied to materials such as metal and glass.	May be used with JP-4, diester fluids and motor oils. Not organic solvents, ketone, etc.	Static friction 0.05 to 0.07, density 1,020 kg/m^3 (8.5 lb/gal) cure, 204°C (400°F), 30 mm. Service temperature 204°C (400°F), maximum 232°C (450°F).
EMRALON® 320	PTFE coating, thermoplastic resin	Air-dry film for heat sensitive materials, light load mechanisms.	Moderate resistance to some inorganic corrosive. Not to organic solvents.	Static friction 0.05 to 0.07 density, 948 kg/m^3 (7.9 lb/gal). Air-dry 2 hr. Service temperature 82°C (180°F); maximum 116°C (240°F).
EMRALON® 321	PTFE coating, thermoplastic resin	Air-dry film, properties similar to EMRALON® 320 but developed for food processing and handling equipment.	Same as EMRALON® 320.	Same as EMRALON® 320.
EMRALON® 327	PTFE coating, thermoplastic resin	Film has low friction and good release properties, easily applied to most materials, metals, wood, glass and plastics.	Similar to EMRALON® 320 and 321.	Static friction, 0.06 to 0.09. Air-dry 2.0 hr. Service temperature 82°C (180°F), maximum 116°C (240°F). In aerosol container.
EMRALON® 328	PTFE coating, thermoplastic resin	Properties and use similar to EMRALON® 327.	See EMRALON® 327.	Same as EMRALON® 327 but in bulk liquid, shelf life 6 months.
EMRALON® 329	PTFE coating, thermoplastic resin	Properties and use similar to EMRALON® 328.	See EMRALON® 320 and 327	Similar to EMRALON® 328.
EMRALON® 330	PTFE coating, resin bond	Excellent adhesion, low friction, resistant to corrosion, abrasion, flex and impact. Applied to metals, wood, rubber and some plastics; on sliding, rubbing or turning surfaces.	-	Friction, 0.07 to 0.05, cure at 177°C (300°F), 1.0 hr. Service temperature 135°C (275°F), maximum 177°C (300°F).

BALL BROTHERS RESEARCH CORPORATION				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
VAC KOTE BPS 18.07	MoS_2 lube solids, organic binder, xylene/alcohol	Sliding surfaces, low and high loads, low to high temperature, air to hand vacuum, space environment. Low corrosion resistance.	Not LOX or rocket fuels. Compatible with jet fuel, hydrocarbons, and solvents.	Cure, 149°C (300°F), 1.0 hr. Friction coefficient, 0.04 to 0.20. Usable temperature range, low, -184°C (-300°F) to high, 288°C (550°F). Rated satisfactory for vacuum outgassing per MSFC - 50M02442.
VAC KOTE 21207	MoS_2 and proprietary application process	Ball bearings, ball bushings. Instrument gears, high loads, hard vacuum, space environment. Corrosion protection properties are not good.	Not LOX or rocket fuels. Compatible with jet fuels, hydrocarbons and solvents.	No cure cycle needed. Friction coefficient, 0.03 to 0.20. Usable temperature range; air, low -268°C (-450°F) to high 149°C (300°F); in vacuum, -268°C (-450°F) to 371°C (700°F). Rated satisfactory for vacuum outgassing per MSFC - 50M02442.

BEL-RAY COMPANY, INC. - "MOLYLUBE"				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
MOLYLUBE® AR	MoS_2 microfine, resin bond	General purpose dry film for high loads or speed, machine tools, sleeve bearing, threaded connections. Will reduce fretting, galling and seizing. May be used on most materials.	Resists most solvents, hydrogen fluids, fuels, and liquid oxygen.	Air-dry film, cure temperature, 6.0 hr.; usable temperature range -73°C to 399°C (-100°F to +750°F).
MOLYLUBE® SR	MoS_2 microfine, and resin bond	Long-life dry film for excellent antigalling and seizing properties when exposed to high bearing loads and temperature. For sliding and rolling surfaces. Provides corrosion resistance.	Not LOX or rocket fuels. Has chemical resistance to oils, greases, some solvents, acids and alkalis.	Heat cured film; cure 177°C (350°F), 30 min.; brush, spray or dip. May be applied without surface pretreatment. Usable temperature range -73°C to 399°C (-100°F to +750°F).
MOLYLUBE® N	MoS_2 inorganic-organic resin bond	Dry film for extreme temperature and LOX applications. Has good adhesion and may be used on ball joints, rod end actuators, etc. For vacuum use also.	LOX insensitive may be used with most chemicals, and solvents.	Heat cure; 83°C (180°F), 2.0 hr. Higher heat cycle improves film hardness; usable temperature range, -184°C to 760°C (-300°F to +1400°F). Meets MIL-L-81329 requirements.
MOLYLUBE® Spraycote	MoS_2 blended solvents and bonding agent	For excellent lubricity, extreme pressure and rust protection. To prevent galling and seizing on rolling and sliding surfaces. Machine tools, machinery, mechanisms, etc.	Not for LOX or oxygen.	May be applied by aerosol can, brush, dip or spray; rapid air-dry.

CERAC, INC.				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
BORON NITRIDE	BN	-	-	"CERAC" family of dry lubricant powders consist of noncarbon, low friction compound; same as listed. Particle size of powders 5 x 10^{-6} m. (5.0 μ). Powders may be hot-pressed, combined with oils, solid matrix with other materials, flame sprayed, and combined with resins. Most materials can be used in vacuum and high temperature.
CHROMIUM SULFIDE	Cr_2S_3	-	-	
CHROMIUM SELENIDE	Cr_2Se_3	-	-	
CHROMIUM TELLURIDE	Cr_2Te_3	-	-	
HAFNIUM SULFIDE	HfS_2	-	-	
HAFNIUM SELENIDE	$HfSe_2$	-	-	
HAFNIUM TELLURIDE	$HfTe_2$	-	-	
MOLYBDENUM SULFIDE	MoS_2	Locks, gears, pistons, cams.	-	
MOLYBDENUM SELENIDE	$MoSe_2$	-	-	
MOLYBDENUM TELLURIDE	$MoTe_2$	-	-	
NIOBIUM SULFIDE	NbS_2	-	-	
NIOBIUM SELENIDE	$NbSe_2$	Elect. contacts, motor brushes.	-	
NIOBIUM TELLURIDE	$NbTe_2$	-	-	Also available in aerosol container with proprietary binder-carrier.
TANTALUM SULFIDE	TaS_2	Precision instruments.	-	
TANTALUM SELENIDE	$TaSe_2$	-	-	
TANTALUM TELLURIDE	$TaTe_2$	-	-	
TITANIUM SULFIDE	TiS_2	-	-	
TITANIUM SELENIDE	$TiSe_2$	-	-	
TITANIUM TELLURIDE	$TiTe_2$	Vacuum elect. contacts.	-	
TUNGSTEN SULFIDE	WS_2	Screws and moving parts at temp.	-	
TUNGSTEN SELENIDE	WSe_2	Vacuum switches, valves, bearing.	-	
TUNGSTEN TELLURIDE	WTe_2	-	-	
VANADIUM SULFIDE	VS_2	-	-	
VANADIUM SELENIDE	VSe_2	-	-	
VANADIUM TELLURIDE	VTe_2	-	-	
ZIRCONIUM SULFIDE	ZrS_2	-	-	
ZIRCONIUM SELENIDE	$ZrSe_2$	-	-	
ZIRCONIUM TELLURIDE	$ZrTe_2$	-	-	
SILICONE SPRAY	Silicone and nontoxic carrier-binder	Release agent and lubricant, for sliding surfaces, repels moisture and prevents corrosion. May be used in food processing equipment (Approved by USFDA).	-	Odorless, heat stable at -40°C to 227°C (-40°F to 440°F). In aerosol can. Fast drying.
FLUOROCARBON SPRAY	Fluorocarbon spray and volatile carrier	May be applied to almost any material for sliding surface contact or as release agent. Good bond strength and long-wearing film.	Not compatible with LOX or rocket fuels. Insoluble in organic solvents, acids, oils and water.	Nonstaining, odorless and heat-stable at -40°C to 260°C (-40°F to 500°F). In aerosol containers.

CERAC, INC.				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
CERAC SP-111	MoS_2, inorganic binder (proprietary)	Machinery and equipment maintenance, gears, cams, threads, bearings, universal joints, etc. May be used for metal working dies, and as mold release.	Not LOX or fuel compatible. Resist most chemicals.	Rapid dry, nonflammable, nontoxic, nonconductive. Temperature range, -149°C to 399°C (-300°F to 750°F).

DOW CORNING CORPORATION				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
MOLYKOTE® 106 (MIL-L-8937)	MoS_2 - solid lube blend, thermo-setting resin	Prevent fretting, galling and seizing under high loads, low speed and temperature extremes. Use in dirty or abrasive environments, where mating surfaces are inaccessible to relubricate. For wear-in of new or rebuilt equipment. Good wear-life.	Not LOX or rocket fuels. Resists most hydrocarbon fluids, hydraulic fluid, engine oils and jet fuels.	Heat cured; 149°C(300°F), 1.0 hr. Usable temperature range -198°C to 232°C (-325°F to 450°F). Storage stability, 2 years.
MOLYKOTE® X-15 (MIL-L-81329)	MoS_2, graphite and sodium silicate	Prevent galling in high vacuum. For use on sliding surfaces; rolling and oscillating ball and plain bearing for radial and thrust load.	Compatibility with LOX; N_2O_4 and UDMH.	Air-dry 24 hr. Heat cure, 2 hr. at 82°C (180°F) and 2 hr. at 149°C (300°F). Resist radiation. Usable temperature range -198°C to 649°C (-325°F to 1200°F). Storage stability, 6 months.
MOLYKOTE® M-88	MoS_2 and lube blend, fast air-dry resin binder	Low friction and wear under high loads. Used on: office machinery, vending machines, chains, pivot pins, switches, hinges, etc.	Not LOX, fuels or solvents.	Rapid air-dry film. Usable temperature -198°C to 232°C (-325°F to 450°F). Storage stability, 1.0 year.
MOLYKOTE® Spraykote	MoS_2 (microsize), organic binder	Low friction and moderate adhesion. Resist high pressure. Prevents galling and seizing, wear-in damage. Good in dirty or abrasive atmosphere. Moderate corrosion protection.	Not LOX, fuels or solvents. Compatible with some lube fluids.	Wide temperature range -73°C to 399°C (-100°F to 750°F). Good storage stability. Available in aerosol container.
MOLYKOTE® 321	MoS_2 and blended solid lubricants, and inorganic binder	Prevent galling, seizing and fretting for, cutting tools, machinery pin, levers, splines and threaded parts. Similar properties as X-15, good as aluminum lube.	Compatibility with VDMH, LOX (Batch Test Required), most fuels and solvents.	Air-dry film, good chemical stability. Usable temperature range -198°C to 649°C (-325°F to 1200°F). Storage stability, 6 months.
MOLYKOTE® 523	Modified TFE and fast dry inorganic binder	Sliding surfaces, metal forming, and a release agent. Good adhesion and low friction. Chemically inert. For low loads.	Not LOX or rocket fuels. Resist most chemicals and solvents.	Air-dry, 5 min. Usable temperature -198°C to 260°C (-325°F to 500°F).
MOLYKOTE® M-8800	MoS_2 graphite and organic resin	High loads and extreme temperature. Reduce fretting, galling, etc. For dirty and abrasive environments. For wear-in of equipment, and where parts are not easily lubricated. Has good chemical resistance and endurance life approaches heat cured films.	Not LOX or rocket fuels.	Air-dry film, cured at room temperature, 4 hr. or 250°F, 5 min. Usable temperature range -198°C to 232°C (-325°F to 450°F). Storage stability; 2 years (bulk) or 1.0 year (aerosol can).

DOW CORNING CORPORATION				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
MOLYKOTE® 273	MoS_2 and thermoset resin	Properties and usage are similar to MOLYKOTE® 106. Has good adhesion and chemical resistance. Contains no graphite.	See MOLYKOTE® 106.	Heat cure, 149°C (300°F), 1.0 hr. Usable temperature range -226°C to 232°C (-375°F to 450°F). Storage stability, 1 year.
DOW CORNING® 3400A (MIL-L-46010A) (RIA-PD-42)	Blended lube solids and additives, thermoset resin	For bearing surfaces and similar applications. Extreme pressure solid film for bearing surfaces and has very good corrosion resistance. High friction during wear-in.	Not LOX or rocket fuels. Satisfactory with synthetic and petroleum hydraulic fluids, solvents, cleaning fluids, jet fuel, gasoline, lube oils, etc.	Heat cure, 204°C (400°F), 1.0 hr. Usable temperature range, -198°C to 482°C (-325°F to 900°F). Storage stability, 1 year.
DOW CORNING® 3402 (MIL-L-23398B) (RIA-PD-703) (RIA-PD-42) (MIL-L-40147)	Blended lube solids and additives, organic resin	Properties and usage are similar to MOLYKOTE® 106. This film is considered an air-drying alternative for MOLYKOTE® 106 and DOW CORNING® 3400A. Extreme pressure lubricant, has good corrosion protection.	See MOLYKOTE® 106 and DOW CORNING® 3400A.	Air-dry in 20 min. (for touch), maximum hardness in 24 hr. Usable temperature range, -198°C to 316°C (-325°F to 600°F).
DOW CORNING® 1-3943 (AFSL-41)	MoS_2 and blended solid lubes, and air-cure silicone resin	Specially formulated as an antifretting lube for titanium. Based on Air Force Laboratory developments.	Not LOX or rocket fuel, nor most fluids, chemical solvents.	Air-dry 75 hr. Usable temperature range, -198°C to 427°C (-325°F to 800°F).

DRILUBE COMPANY				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
DRILUBE 1A (MIL-L-8937)	MoS_2, graphite and phenolic resin	High pressure and moderate elevated temperatures. For sliding and rolling surfaces; used in aircraft, automotive, electronic and other manufacturing. Temperature range -184°C (-300°F) to 260°C (500°F) (air), 343°C (650°F) (vacuum).	Not LOX or N_2O_4 or N_2H_4. Resists water, solvents and hydrocarbons.	Heat cure: 204°C (400°F) for 20 min. Spray application recommended. DRILUBE 1B is similar but does not meet MIL-SPEC.
DRILUBE 90	MoS_2, $SrCrO_4$ and alkyd-epoxy resin	Low cost, corrosion inhibited dry film for medium duty. Principally for sliding surfaces. Can be applied to most metals. Maximum temperature 260°C (500°F) (air).	Not LOX or N_2O_4 or N_2H_4. Resists water, solvents and hydrocarbons.	Heat cure: 204°C (400°F) for 30 min. Dip or spray application. Indefinite storage.
DRILUBE 207 (A, B & C)	Graphite and epoxy blend resin	General usage film lube for conductive surfaces, sliding or rolling. Fair wear-life; temperature range -184°C (-300°F) to 260°C (500°F) (air), 316°C (600°F) (vacuum).	Not LOX or N_2O_4 or N_2H_4. Resists water, and some solvents.	Moderate storage life; spray application. Heat cure: 207A, 191°C (375°F), 1.0 hr.; 207B, 121°C (250°F), 1.0 hr.; 207C, catalyst cure.
DRILUBE 701 (702)	MoS_2, $SrCrO_4$ and phosphoric binder	Very smooth dry film and good adhesion properties. Has good antigalling properties over wide temperature range -240°C (-400°F) to 371°C (700°F) (air), 649°C (1200°F) (vacuum). Wear-life is poor to moderate.	LOX compatible. Not N_2O_4 or N_2H_4. Resists water and most solvents.	Heat cure: 204°C (400°F), 1.0 hr. 701, spray or dip application. 702, brush application. Toxic fumes.
DRILUBE 805	MoS_2 and ceramic binder	High load capacity film lube for sliding or rolling contact. Withstands high temperature 371°C (+700°F) (air), 649°C (1200°F) (vacuum). Moderate moisture and solvent resistant.	LOX compatible. Not N_2O_4 or N_2H_4.	Heat cure: 2 hr. at 82°C (180°F), 4 hr. at 204°C (400°F). Spray application recommended. Is not compatible with graphite film.
DRILUBE 831	Teflon and fluorinated hydrocarbon (evaporated)	Excellent lubricity and good wear-life for sliding surfaces at room temperature. Also good as sealant. Maximum temperature 232°C (450°F).	Compatible - LOX, N_2O_4, N_2H_4 and UDMH. Resists water and solvents.	Air-dry; dip or spray application. Mildly toxic vapors above 260°C (500°F). Good storage life. Also available in aerosol containers as DRILUBE 842.

DRILUBE COMPANY				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
DRILUBE 861	WS_2 and ceramic binder	High cost dry-film lube with good high temperature wear-life but poor wear-life at room temperature. Can be used in vacuum. Maximum temperature 399°C (750°F) (air), 760°C (1400°F) (vacuum).	LOX compatible. Not N_2O_4 or N_2H_4. Fair resistance to water and solvents.	Heat cured: 1.0 hr. in air; 2 hr., 82°C (180°F) and 4 hr., 204°C (400°F). Spray application.
DRILUBE 867	$MoSe_2$ and ceramic binder	Very expensive dry-film lube for extreme temperature and high vacuum. Temperature ranges: (air) 427°C (800°F) continuous, short time to 649°C (1200°F); (vacuum) 816°C (1500°F) continuous, short time, 1093°C (2000°F). Cryogenic use also.	Same as DRILUBE 861.	Same as DRILUBE 861.
DRILUBE 868	$MoTe_2$ and ceramic binder	Very expensive dry-film lube has similar mechanical and physical properties to DRILUBE 867.	Same as DRILUBE 861.	Same as DRILUBE 861; 6-month storage life.
DRILUBE 869	WSe_2 and ceramic binder	Very expensive dry-film lube for cryogenic and high temperature applications, also usable in vacuum.	Same as DRILUBE 861.	Same as DRILUBE 861; 6-month storage life.
DRILUBE 870	WTe_2 and ceramic binder	Similar in properties and usage to DRILUBE 869.	Same as DRILUBE 861.	Same as DRILUBE 861; 6-month storage life.

DRI-SLIDE, INC.				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
DRI-SLIDE®	MoS_2 powder, 0.50×10^6 m. (0.50 μ), light hydrocarbon petroleum liquid. Anticorrosive additives.	Lubricant under adverse conditions; dust, water, dirt and alkalis. General purpose; elect. equipment, small mechanisms, office machinery, vending machine, machine tools, automotive, etc. May be used to impregnate laminated bushings and slide pads, rub strips.	Resist most acids, alkalis, water. Compatible with greases and oils.	DRI-SLIDE® provides considerable rust or corrosion protection. Temperature range, -46°C to 399°C (-50°F to +750°F). Should not be applied at more than 52°C (125°F) (flash point of carrier 71°C (160°F)). Nontoxic and dust free.

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ELECTROFILM CORPORATION				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
LUBE-LOK 66-C	MoS_2 - graphite, corrosion inhibitors in thermoset resin	General purpose light to heavy duty lube for fretting and sliding surfaces. Dry film for corrosive environments where low friction is needed.	Not LOX or rocket fuels. Satisfactory with most hydrocarbon fuels, oils and solvents.	Cure at 191°C (375°F) 1.0 hr. Usable temperature range, -184°C to 371°C (-300°F to 700°F).
LUBE-LOK 1000	Graphite-lead oxide, ceramic binder	Heavy duty film for fretting and sliding metal surfaces operating at high temperatures.	LOX and hydrocarbon fuels, oils and solvents. Limited use with jet fuels.	Cure at 538°C (1000°F) for 15 min. Usable temperature, -184°C to 1093°C (-300°F to 2000°F).
LUBE-LOK 2006	MoS_2-graphite in silicone-formaldehyde resin	Wide temperature range solid film for sliding and fretting surfaces; cams, threaded connections, plain or spherical bearings.	Not LOX or rocket fuels. OK with most hydrocarbon fuels, oils and solvents.	Cure at 260°C (500°F) 2.0 hr. Usable temperature range, -184°C to 454°C (-300°F to 850°F).
LUBE-LOK 2109 (MIL-L-46010)	MoS_2-lead thermoset resin	Solid film for sliding motion, plain and spherical bearings, hinges, cams and threaded applications. High load carrying capacity.	Not LOX or rockets. OK with most hydrocarbon fuels, oils and solvents.	Cure at 149°C (300°F) 2.0 hr. Usable temperature range, -251°C to 316°C (-420°F to 600°F).
LUBE-LOK 2306 (NASA 1367)	MoS_2, and inorganic binder	Solid film for high vacuum ball and roller bearings, spherical bearings and sliding applications.	LOX and hydrocarbon fuels and oils. Limited solvent use.	Cure 82°C (180°F), 2.0 hr. plus 204°C (400°F), 2.0 hr. Usable temperature range, -251°C to 427°C (-420°F to 800°F).
LUBE-LOK 2396 (MIL-L-81329)	MoS_2-graphite in inorganic binder	Solid film for rolling element bearings.	OK with LOX, rocket fuels, hydrocarbon fuels, and oils. Limited use with solvents.	Cure at 82°C (180°F), 2.0 hr. plus 204°C (400°F) 2.0 hr. Usable temperature range, -251°C to 459°C (-420°F to 850°F).
LUBE-LOK 2406	Graphite and inorganic binder	Wide temperature range solid film. For use where compatibility with N_2O_4, N_2H_2 and aerozem are required.	OK with LOX, rocket fuels, hydrocarbon fuels and oils. Limited solvent use.	Same cure cycle and usable temperature range as LUBE-LOK 2396.
LUBE-LOK 2606	WS_2 and inorganic binder	Solid film for temperatures exceeding normal requirements of MoS_2 or where MoS_2 cannot be used.	OK with LOX, rocket fuels, hydrocarbon fuels and oils.	Cure at 82°C (180°F), 2.0 hr. plus 204°C (400°F) 2.0 hr. Usable temperature range, -184°C to 510°C (-300°F to 950°F).

ELECTROFILM CORPORATION				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
LUBE-LOK 5306	MoS_2 and thermoset resin	Low coefficient of friction solid film with excellent load and endurance properties.	Not LOX or rocket fuels. OK with most hydrocarbon fluids.	Cure at 149°C (300°F) 1.0 hr. Usable temperature range, -184°C to 316°C (-300°F to 600°F).
LUBE-LOK 5396	MoS_2 - graphite thermoset resin	Same as LUBE-LOK 5306 but contains graphite.	See LUBE-LOK 5306.	Same as LUBE-LOK 5306.
LUBRI-BOND A (MIL-L-23398)	MoS_2 - graphite phenolic resin	General purpose solid film may be used for production, touch-up, and field repair.	Compatible with hydrocarbon fluids.	Air-dry; available in bulk or aerosol containers. Usable temperature range, -184°C to 316°C (-300°F to 600°F).
LUBRI-BOND J (MIL-G-26548)	Graphite phenolic resin	General purpose solid film for film touch-up where MoS_2 cannot be used or where electrical conductivity is required.	Compatible with hydrocarbon fluids.	Air-dry; available in bulk or aerosol containers. Usable temperature range, -129°C to 316°C (-200°F to 600°F).
LUBRI-BOND M	MoS_2 and Freon carrier	Touch-up film where graphite and resin cannot be used. Mold release and cold heading applications.	LOX and rocket fuels, hydrocarbon fluids.	Air-dry. Usable temperature range, -73°C to 371°C (-100°F to 700°F).
LUBRI-BOND N (WS 9004)	$NbSe_2$ and phenolic resin	Solid film where extremely high electrical conductivity is required. Medium load carrying capacity.	Compatible with hydrocarbon fluids.	Air-dry. Usable temperature range, -73°C to 371°C (-100°F to 700°F).
ELECTRO-MOLY GRADE I (MIL-M-7866)	MoS_2 powder	High purity small particle size MoS_2.	LOX and rocket fuels, hydrocarbon fluids.	Usable temperature range, -196°C to 371°C (-320°F to 700°F).
ELECTRO-GRAPH (MIL-G-6711)	Graphite powder	High purity small particle size graphite.	LOX and rocket fuels, hydrocarbon fluids.	Usable temperature range, -196°C to 1093°C (-320°F to 2000°F).
LUBRI-BOND HT (AFSL-41)	MoS_2-Sb_2O_3 silicone binder	High temperature film developed for rubbing surfaces; antifretting, antigalling and antiseize. Primarily for use on titanium. Based on Air Force Laboratory development.	Compatible with most hydrocarbon fluids and solvents.	Air-dry, 72 hr., Usable temperature range, -196°C to 399°C (-320°F to 750°F).
LUBE-LOK 2696	WS_2-graphite and inorganic binder	Solid film for temperatures exceeding normal requirements of MoS_2 and strong oxidizing atmospheres.	Same as LUBE-LOK 2606	Same as LUBE-LOK 2606.
LUBE-LOK 4396	MoS_2-graphite and phenolic binder	Solid film for highly loaded, high speed use. Compatible with dissimilar metals.	Not LOX or rocket fuels, OK with most hydrocarbon fluids.	Cure at 191°C (375°F) 1.5 hr. Usable temperature range, 184°C to 316°C (-300°F to 600°F).

EVERLUBE CORPORATION				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
EVERLUBE 620 & 620A (MIL-L-8937) (MIL-L-25504) (MIL-L-22273)	MoS_2 and modified phenolic resin, 620A also contains a buffered corrosion resistant agent.	Dry film to reduce wear, prevent galling and provide antiseize properties. Good for extreme loads and high temperature.	Compatible with hydrocarbon fluids.	Cure at 191°C (375°F) for 1.0 hr. 620A cures 121°C (250°F) in 2.0 hr. Usable temperature range -221°C (-365°F) to 260°C (500°F) for dynamic load. To 343°C (650°F) dynamic.
EVERLUBE 626	MoS_2 and modified phenolic resin	Film to reduce wear, prevent galling and provide antiseizing properties. Also a hard coating that is corrosion and abrasion resistant.	Not for LOX, hard vacuum, or radiation. OK for most hydrocarbon fluids.	Cure 149°C (300°F) for 1.0 hr. Usable temperature range -221°C to 260°C (-365°F to 500°F).
EVERLUBE 810 & 810M	MoS_2-graphite and soft metals in a silicone resin	Reduce wear and prevent galling and seizure of metals at high temperature. For use on corrosion-resistant and high temperature alloy metals. <u>810M</u> is modified for extended wear-life in bearing applications.	Not for LOX, hard vacuum, high radiation or strong oxidizers. O.K. for most hydrocarbon, chemical, gases, etc.	Cure at 288°C (550°F) for 1.0 hr. Recommended temperature range 316°C to 538°C (600°F to 1000°F), also stable down to -54°C (-65°F).
EVERLUBE 811 (MIL-L-81329)	MoS_2-graphite, sodium silicate	Extreme pressure and temperature film. Lube to reduce wear and galling. Recommended for use in dry applications. Good vacuum and radiation properties.	Compatible with LOX, N_2O_4, IRFNA, strong oxidizers, etc. O.K. with most fluids.	Cure at 66°C (150°F) for 2.0 hr plus 204°C (400°F) for 2.0 hr, may be reduced to 149°C (300°F) for aluminum. Usable temperature range, -221°C (-365°F) to 649°C (1200°F).
EVERLUBE 812 (MIL-L-81329)	MoS_2 and sodium silicate	Graphite free film with properties similar to EVERLUBE 811.	Not for strong oxidizers, N_2O_4, IRFNA etc.	Cure same as 811. Usable temperature range -251°C (-420°F) to 399°C (750°F).
EVERLUBE 823	Graphite and sodium silicate	Solid film containing no MoS_2, properties similar to 811 and 812, but is not as good a lubricant as films with MoS2. Recommended for possible exposure to UDMH, N_2O_4, IRFNA, N_2H_2 (hydrazine and aerozene fuels), not for extended endurance life.	Not for LOX, but satisfactory with most fluids.	Cure same as 811. Usable temperature range same as 811.

EVERLUBE CORPORATION				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
INLOX® 44 & 88	MoS_2-graphite, phosphoric acid binder (also available graphite free)	Film for cryogenic use, reduce wear, prevent galling. INLOX® has good wear-life, while INLOX® 88 is an antiseize coating for threads, fittings, couplings, etc.	LOX and most hydrocarbon fluids.	Cure at 191°C (375°F) for 1.5 hr. Usable temperature range -240°C to 371°C (-400°F to to 700°F).
ECOALUBE® 642 (MIL-L-46010A)	MoS_2-metallic oxides, corrosion inhibitors, resin binder	Solid film has low friction, reduces wear, and good corrosion resistance.	Not LOX, but OK for jet fuel, hydrocarbons, hydraulic fluids, silicones, etc.	Cure at 204°C (400°F) for 1.0 hr. Usable temperature range -185°C to 260°C (-365°F to 500°F).
EVERLUBE 967	MoS_2-corrosion-resistant compound--antioxidant and high temperature binder	Solid film for extreme loads, wide temperature range, reduces wear, prevents galling and has very good endurance life.	Not LOX, resistant to hydrocarbon, hydraulic fluids, oils, greases.	Cure at 66°C (150°F), 1.0 hr. plus 302°C (575°F) for 1.0 hr. Usable temperature range -149°C to 399°C (-300°F to 750°F).
EVERLOX 16, 17, & 18	MoS_2, chemically bonded	Used on aircraft, missiles, rocket engines, space vehicles and industrial applications. Reduces wear and prevents galling. Cryogenic lubricant typical application: fittings, valves, fasteners, etc.	LOX, gaseous oxygen and liquid hydrogen approved under MSFC-106A.	EVERLOX 16, cured at 149°C (300°F), 1.0 hr. EVERLOX 17 is for brush-on where parts cannot be baked. EVERLOX 18 is a paste for field and shop application.

FEL-PRO, INC. (Division, Felt Products Manufacturing Company)				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
FEL-PRO C-200	46% lubricant, 6% thermosetting resin, 48% organic carrier	Baked-on dry film for high temperature medium speed and heavy loads. Prevents corrosion, galling, seizing and wear. Uses include missile and aircraft components, actuators, gears, journals, bearings, hinge pins, etc.	Resist most hydrocarbon fluids and compounds.	Resin-bonded dry film; bake temperature 260°C (500°F), 15 min. Friction coefficient, 0.07 to 0.11. Usable temperature range, -54°C to 816°C (-65°F to 1500°F) (limited to 1316°C (2400°F)). Vacuum stable and good shelf life.
FEL-PRO C-300	49% lubricant, 7% resin, 44% solvent	Air-dry, solid-film lubricant for high temperature. Usage industries include aerospace, automotive, machinery, household, petrochemical, etc. Recommended for sliding, rolling and rotating surfaces.	Fluid resists JP-4, hydraulic fluid (nonpet.), brake fluid, synthetic lub. oil, lub. oil, silicone fluids, and trichloroethylene; not LOX.	Air-dry resin-bonded dry film (best properties obtained with heat cure; 1/2 hr., 260°C (500°F) for 3-1/2 hr. at 375°F). Friction coefficient, 0.07 to 0.11. Usable temperature range, -54°C to 649°C (-65°F to +1200°F). Vacuum stable and good shelf life.
FEL-PRO C-640 (MIL-L-8937)	MoS_2 plus solid lube powders and modified phenolic resin.	Solid film has exceptionally high solvent and corrosion resistance, also good wear-life.	Not LOX; resistant to: hydrocarbon fluids, gasoline, jet fuel, hydraulic fluids, oils, silicones, etc.	Cure at 163°C (325°F) for 1.0 hr. Temperature stable from -54°C (-65°F) to 260°C (500°F).
FEL-PRO 651A (MIL-L-46010A)	MoS_2 plus pigment lubes and epoxy-phenolic resin (graphite free)	Solid film has excellent wear-life, corrosion and release properties.	Similar to FEL-PRO C-640.	Cure at 204°C (400°F) for 1.0 hr. Temperature stable range is the same as C-640.

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GENERAL MAGNAPLATE CORPORATION				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
TURFRAM® *	Treated aluminum surface impregnated with magnaplate TFE particles	Sliding surfaces, dies, molds, electrical equipment, bearings, valves, pumps, power transmission equipment, etc.	Most hydrocarbon fluids, solvents, oils, chemicals, etc.	Aluminum only: Hard wear-resistant surfaces, greater abrasion resistance than case-hardened steel or hard chrome. TFE polymer surface has low friction, corrosion, improved electrical resistance and rapid heat transfer.
MAGNALUBE® D-4821	Matrix-bonded molybdenum solid film	Low friction solid film, prevents galling, seizing, and cold welding. Good for high temperature, high bearing pressure and high surface speeds. Also withstands humidity and atmospheric conditions.		Heat-cured solid film, can be applied to ferrous and nonferrous alloys. Ferrous metals require phosphate or vapor blast pretreatment, aluminum anodizing. Curing temperature, 121°C to 177°C (250°F to 350°F) for 1.0 hr.; 1-year storage life.
MAGNALUBE® D-5261	Dry-film lubricant suspended in a suitable carrier	Low friction dry film for reduced wear and parts subject to seizing and galling. Machine shop, truck and automotive, etc. Spray, dip or brush application.	Resists jet fuel, aviation gasoline, lub. oils, petroleum hydraulic fluids, fluids, and hydrocarbons.	Air-dry self-bonding dry-film lubricant. Has good adhesion to pretreated metal surfaces. Usable temperature range, -54°C to 260°C (-65°F to +500°F); 1.0 hr. shelf life. May be obtained in aerosol containers.
MAGNALUBE® D-801	MoS_2 modified resin binder	Low friction dry film for wide pressure range, temperature and surface speed. Prevents galling, seizing, cold welding and fretting corrosion. Break-in lubricant, gears, cams, pins, etc.	Resists humidity, oils, greases, acids, solvents and alkalis.	Heat-cured dry film; 1.0 hr., 191°C (375°F), for treated metal surfaces.
HI-T-LUBE®	Low shear metallic film impregnated with MoS_2 (electroplate)	Aircraft and missile parts requiring wide temperature range, high loads and severe environmental conditions. Bearings, screws, gears, sliding surfaces. Not intended for corrosion resistance in warm acids. For high moisture condition base coat pretreatment is necessary to prevent moisture break through.	Impact sensitive in LOX. Not compatible with most missile and aerospace propellants. Compatible with space, gaseous and liquid oxygen, nitrogen, hydrogen, helium and most solvents and chemicals.	Proprietary dry-film lubricant for severe conditions. Usable temperature range, -54°C to 538°C (-65°F to +1000°F).

GENERAL MAGNAPLATE CORPORATION				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
NEDOX®*	Electrodeposited porous hard nickel-chrome impregnated with PTFE*	Proprietary film for steel, stainless steel, brass and copper alloys. Properties and usage are similar to TURFRAM®*	Same as TURFRAM®	Friction coefficient is 0.04. Resistant to abrasion, corrosion and most chemicals. Usable temperature range from cryogenic to 260°C (500°F).
CANADIZING®*	Electrochemical process gives titanium a hard surface impregnated with a fluorocarbon (TFE), MoS_2 or graphite, also colors.	Proprietary film for titanium, provides a hard, corrosion-resistant, low friction surface. Usage includes: aircraft, naval craft and ordnance, packaging machinery, air and hydraulic tools, etc.	Same as TURFRAM®	Properties similar to TURFRAM® and NEDOX®. Usable temperature range from cryogenic to 371°C (700°F).

* Can be used for build up of worn or undersized dimension. All add the characteristic quality of increased surface hardness of the bare metal.

H. A. HENDERSON COMPANY				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
HENDERLUBE 402A (MIL-L-8937)	MoS_2/graphite/ lubricative anti-oxidants; modified phenolic resin binder	Sliding surfaces, splines, bolts, nuts, threaded parts, antiseize. Use on ferrous metals, nonferrous metals, fibre and plastics, glass and ceramics; usable at high speed and loads.	LOX resistant marginal - not recommended. Resistant to hydrocarbons, solvents, hydraulic fluid, oils, greases, etc.	Good wear-life and corrosion resistance. Usable temperature range -73°C to 260°C (-100°F to 500°F), cure at 149°C (300°F), 30 min. Dry-film coating will not support growth of fungus or mold (MIL-E-5272A).
HENDERLUBE 462A	MoS_2/graphite/ metallic salts; thermosetting silicone resins	Medium high-heat dry film for temperature range -73°C to 454°C (-100°F to +850°F); prevents galling, seizing, wear and corrosion. Similar applications to HENDERLUBE 402A.	Not recommended for hydrocarbons, solvents, and similar items.	Has good high temperature properties, but is not fuel or solvent compatible. Cured at 260°C (500°F).
HENDERLUBE 413 (MIL-L-46010)	Compounded thermosetting dry film; (no graphite or powdered metal), modified epoxy resin.	For bearing and sliding surfaces. Properties are similar to 402A, but has slightly better wear-life and corrosion resistance. Very good coating for steel, carbon and stainless, and is replacing 402A on these surfaces.	Same as HENDERLUBE 402A.	Cure at 177°C (350°F) for 1.0 hr. See note for HENDERLUBE 402A.

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HOHMAN PLATING AND MANUFACTURING, INC.				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
SURF-KOTE® 108	MoS_2 modified, resin bonded	Economical film, excellent where large quantities of small parts are coated by dipping or tumbling. May also be sprayed or brushed. Prevents seizing, cold welding, fretting, corrosion and has very good wear-life.	Resistant to humidity, oils, greases, solvents, acids and alkalis.	Cure at 204°C (400°F) for 1.0 hr.
SURF-KOTE® 359	TFE pigment phenolic resin	Low temperature cure film, has excellent adhesion and corrosion resistance.	Resists hydraulic fluids, oils, most solvents (not esters and ketones).	Cure at 149°C (300°F) for 1.0 hr. Continuous operating temperature limit 177°C (350°F), short duration limit 204°C (400°F).
SURF-KOTE® 360	TFE pigment, modified alkyd binder	Water despersible dry film for use on elastomeric parts and where flexibility is required (i.e., 'O' rings, seals, etc.).	Resistant to oils, hydraulic fluids, etc.	Cure at 149°C (300°F) 1.0 hr.
SURF-KOTE® 1284 (MIL-L-8937)	Matrix-bonded film containing MoS_2	Eliminates galling, seizing, cold welding, prevents fretting, corrosion and lubricates under extreme pressure and temperatures. May be used at high surface speeds.	Compatible with hydrocarbon fluids.	Cure at 177°C (350°F) for 1.0 hr.
SURF-KOTE® 1625	Lubricant pigment in an air-drying resin	Film for bearing or rubbing surfaces; has good adhesion and low friction. Prevents wear, seizing and galling. Uses include: assembly line, machine shop, automotive, baking, house and office equipment.	Resistant to: hydrocarbons - aviation gas, petroleum hydraulic fluid, lubricating oils, jet fuel.	Air-dry in 30 min. or cured at 149°C (300°F) 15 min. Usable temperature range -54°C to 260°C (-65°F to 500°F). Available in bulk or aerosol container.
SURF-KOTE® LO-1800	MoS_2-lube pigments in an inorganic binder	Nonflammable film for application in a vacuum or liquid oxygen.	Liquid oxygen and hydrocarbon fluids.	Cure at 149°C (300°F) 2.0 hr. May be used in air up to 399°C (750°F).
SURF-KOTE® M-2036	MoS_2-lube pigments in polyimide binder (no graphite)	Superior endurance life over wide temperature range up to 399°C (750°F) use on steel, stainless steel and anodized aluminum.	Poor corrosion resistance.	Especially recommended for temperature range 204°C (400°F) to 371°C (700°F) is base material will stand cure. Cure at 93°C (200°F), 1.0 hr and 288°C (550°F), 1.0 hr.
SURF-KOTE® M-2049 (MIL-L-46010)	MoS_2-lube pigments, resin bonded (no graphite or powdered metals)	Material has excellent adhesion and corrosion properties over a variety of materials, and excellent wear-life over a wide range of conditions, and environments including speed ranges and loads.	Resistant to: hydrocarbons, hydraulic fluids, jet fuel, silicone fluids and similar material.	Air-dry 30 min, then cure at 204°C (400°F) for 1.0 hr. Usable temperature range -54°C (-65°F) to 260°C (500°F).

HOHMAN PLATING AND MANUFACTURING, INC.				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
SURF-KOTE(R) A-2178A	MoS_2 and other lubricating pigments in organic resin (similar to AFSL-41)	Good lubricant for titanium. Good for field application where baking is not possible and performance at high temperature is required. Good adhesion and fluid resistance.	-	Air-dry 72 hr, provides maximum endurance life, film usable to 316°C (600°F).

LUBECO, INCORPORATED

MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
LUBECO 905	Chemically bonded inorganic solid dry film lubricant. (No vitreous or ceramic binder). Lubricant constituents are controlled particle size of MoS_2, graphite and several others.	Primarily as an antifriction coating to reduce wear, prevent galling, scoring, seizing or abrasion on ferrous and nonferrous material subject to sliding or rolling contact. Used on spherical ball and sleeve bearings. Screws, cams, bolts, fasteners, coupling, shafts, etc.	ABMA-LOX impact sensitivity test, vacuum hydrocarbon, fluid, etc. Not compatible with most propellants for missiles and aerospace, hydrazine N_2O_4, etc.	Slow chemical bond is accelerated by heat stabilizing 204°C (400°F) on steel and 163°C (325°F) on aluminum. Temperature range -269°C (-452°F) to 260°C (500°F).
LUBECO 2123	Inorganic dry film lubricant, electrophoretic binder system (similar to 905).	Long wear-life under high loads and low speeds at elevated temperature (higher than 905). Particularly successful on titanium.	Resist chemical attack better than most inorganic lubricants. Used in LOX, liquid hydrogen and hard vaccum.	Cure same as 905. Usable temperature range -269°C to 427°C (-452°F to 800°F). Very low friction film.
LUBECO 2023	Similar to 905	Extremely high temperature resistance. Wear-life is slightly lower and friction is a little higher than 2123.	Similar to LUBECO 2123.	Cure same as 905. Usable temperature range -269°C to 649°C (-452°F to 1200°F) for prolonged exposure and to 816°C (1500°F) for short periods.
LUBECO 2023B	Similar to 905	Dry film inert to most any chemical attack: fuels, oxidizers and aggresive chemicals. Good wear-life and lubricity.	May be used with hydrazine UDMH, monomethyl hydrazine, LOX, IRFNA, nitrogen tetroxide, hydrogen peroxide, 75% nitric acid, and diethyltramine.	Cure same as 905.

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MICROSEAL CORPORATION				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
MICROSEAL 100-1	98% Pure graphite, high heat inorganic binder (proprietary)	Sliding surfaces, rotating and oscillatory mechanical hardware. Protective coating in high thermal area. Thermal range: Air -240°C to 1093°C (-400°F/+2000°F); Vacuum 1.33 x 10^{-7} N/m^2 10^{-9} torr 1482°C (2700°F). Can be applied to metals, plastics, rubber, etc.	Liquid oxygen unsymmetrical. Dimethyl hydrazine, nitrogen tetroxide, liquid nitrogen, fluorine, water, hydraulic fluid, grease, silicone salt spray.	Nontoxic, noncorrosive impinged solid lubricant. Special spray applicator required. Cure cycle variable depending on application: room temperature 7 days; heat cure, 15 min. at room temperature, and 232°C (450°F) for 1.0 hr.
MICROSEAL 200-1	MoS_2 and high heat inorganic binder (proprietary)	Similar to MICROSEAL 100-1 except for thermal range: air 371°C (700°F) (max.); vacuum 1.33 x 10^{-7} N/m^2 10^{-9} torr 760 (1400°F).	Similar to MICROSEAL 100-1.	Similar to MICROSEAL 100-1.
MICROSEAL 300-1	Tungsten disulfide high heat inorganic binder (proprietary)	Similar to MICROSEAL 100-1 except for thermal range: Air 482°C (900°F) (max.); vacuum 1.33 x 10^{-7} N/m^2 10^{-9} torr 760°C (1400°F).	Similar to MICROSEAL 100-1.	Similar to MICROSEAL 100-1.

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MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
MEL-1	MoS_2 (DC-sputtering)	Experimental sputtered film primarily for use on ball bearing or other application requiring extremely thin film. May be used in vacuum.	Good outgassing properties.	Usable temperature range (air or vacuum); -73°C (-100°F) to 399°C (750°F).
AFSL-28	Calcium fluoride, barium fluoride, aluminum phosphate	High temperature film developed for use at 538°C (1000°F) in an air environment, where best friction and wear properties are obtained. Best on Ni-based alloys. Developed on an Air Force Laboratory Contract.	No fluids, use dry.	Cure at 925°C (1697°F) for 1.0 min. Usable temperature range in air; 21°C (70°F) to 816°C (1500°F) and in vacuum; -21°C (70°F) to > 538°C (> 1000°F). Relatively high friction.
AFSL-29	Calcium fluoride, barium fluoride, magnesium fluoride, aluminum phosphate	High temperature film that is similar to AFSL-28, but cures at lower temperature and has lower friction. Has very good load capacity and wear-life. Also developed on an Air Force Laboratory Contract.	No fluids, use dry.	Cure at 750°C (1382°F) for 1.0 min. Usable temperature range in air; 21°C (70°F) to 649°C (1200°F).
MLR-2 (50M60434)	MoS_2 and Sb_2O_3, polyimide resin	For severe wear-life and elevated temperature use. Has acceptable outgassing and excellent radiation properties moderately high friction.	Hydrocarbon fluids and gaseous oxygen.	Air-dry 30 min, then cure; 149°C (300°F), 1.0 hr. plus 302°C (575°F), 1.0 hr. Usable from low temperature to 260°C (500°F).
MLF-5 (MSFC 502)	MoS_2, graphite, gold, sodium silicate, water	Good for high temperature and loads. Developed for LOX compatible film. May be used on ball and roller bearings. Excellent radiation and satisfactory outgassing properties.	LOX and gaseous oxygen Not with fluids.	Air-dry 30 min, then cure 82°C (180°F), 2.0 hr. and 149°C (300°F) 8.0 hr. Usable temperature range (air and vacuum); -73°C (-100°F) to 538°C (1000°F).
MLF-9 (MSFC 253)	MoS_2, graphite, bismuth, sodium silicate, water	LOX compatible film, less expensive than MLF-5. Has high load capacity, but other properties are lower than MLF-5.	Same as MLF-5.	Air-dry 30 min, then cure 82°C (180°F), 2.0 hr. and 149°C (300°F) 2.0 hr. Usable temperature range (air or vacuum) -73°C (-100°F) to 371°C (700°F).
MLR-66	MoS_2, Sb_2O_3 polyphenylene sulfide-alcohol	New experimental film has very good load capacity, wear-life and high temperature properties.	Use dry.	Cure at 93°C (200°F) for 1.0 hr. and then 371°C (700°F) 30 min. Usable from room temperature to 427°C (800°F).

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NATIONAL PROCESS INDUSTRIES				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
*VITRO-LUBE (NPI-1220)	MoS_2/graphite Ag and proprietary ceramic binder	Heavy duty, long wearing dry lube; antigalling, anti-fretting, antiseizing, for sliding surfaces. Recommended for dry surfaces. Can be applied to most metals and platings. Developed for the XB-70 airplane.	Should be used dry--fluids severely damage properties	Dry film lube for high temperature and loads. Requires surface preparation and critical application technique, cure at 524°C (975°F), 1.0 min.
NPI-14 (MIL-L-8937) (MIL-L-22273) (MIL-L-25504)	MoS_2/graphite, modified phenolic resin	Corrosion resistance and good wear-life. For high and low loads. For bearing and sliding surfaces.	Resistant to; hydrocarbons, gas, hydraulic fluid, turbine fuel, oil, silicones, and some solvents.	Heat cured solid film lube, resin bonded. Bake temperature 149°C (300°F) 1.0 hr.
NPI-425	MoS_2, SB_2O_3, solvent and polyimide resin	For bearing and sliding surfaces; severe wear-life requirements. Has very good corrosion resistance. Not for cryogenic use and should not be used with other lubricants or in contaminated environments.		Air dry 30 min. and cured at 149°C (300°F), 1.0 hr. plus 302°C (575°F) for 1.0 hr. Usable to 260°C (500°F). Identical to NASA formula MLR-2, licensed and marketed by NPI.
NPI-5	MoS_2, graphite, gold, sodium silicate, water	Dry film good for high load condition. May be used with LOX and gaseous oxygen. May be used on ball and roller bearings. Should be used dry and not with other lubricants.	LOX and gaseous oxygen. Not with fluids.	Air dry 30 min. and cured at 82°C (180°F) for 2.0 hr., then 149°C (300°F) for 8.0 hr. Identical to NASA formula MLF-5, licensed and marketed by NPI.
NPI-2500 (MRIONITE) (AFSL-28)	Calcium fluoride, barium fluoride, aluminum phosphate	High temperature film developed for use at 538°C (1000°F) in air. Works best on nickel-based alloys. Best friction and wear properties are in air.	No fluids.	Cure at 925°C (1697°F) for 1.0 min. Usable temperature range; air, 21°C (70°F) to 816°C (1500°F), in vacuum. 21°C (70°F) to > 538°C (> 1000°F)

* Applied only by NPI.

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POXYLUBE, INC.				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
POXYLUBE 330	Blended dry film (contains MoS_2, graphite, others) and small amount of air-dry resin	Sliding and rolling contacts; machinery break-in, screws, gear trains, T-slots, bolts, universal joints, latches, mechanical mechanisms, general purpose lube, etc.		Paint-like dry-film that air dries in 30 min. Good shelf storage life. Spray, dip, or brush application, some agitation required. Usable temperature -212°C (-350°F) to about 93°C (200°F).
POXYLUBE 420	Similar to POXYLUBE 330, but contains more resin	Similar to POXYLUBE 330	Resists moisture and some fuels and solvents.	Similar to POXYLUBE 330, air dries in 24 hr. Soluble in alcohol or shellac thinner.
POXYLUBE 500-M	Blended dry film (contains MoS_2, graphite, others) and heat cured resin	Similar to POXYLUBE 330 and 420 but has more wear strength, adhesion and chemical resistance.	Not LOX or rocket fuel but most hydrocarbon fluids and solvents, not as good as POXYLUBE 750.	Improved properties over POXYLUBE 330 and 420. Heat cure cycle 149°C (300°F), 1.0 hr. Usable temperature range -212°C to 316°C (-350°F/+600°F).
POXYLUBE 750	Similar lube blend to POXYLUBE 500 but has more resin	Similar to POXYLUBE 500 but slightly improved properties.	Resistant to solvents, gasoline, hydraulic fluids, oils, etc.	Similar to POXYLUBE 500. Cure cycle, 191°C (375°F) 1.0 hr. Usable temperature range -212°C to 260°C (-350°F to 500°F).

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PRODUCT TECHNIQUE, INC.				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
PT-14* TECHLUBE	Microfine MoS_2 and graphite, resin binder	Solid film lube for rolling and sliding surfaces, medium load 27.58 x 10^7 N/m^2 (40,000 psi) and high speed. Temperature range -73°C to 28°C (-100°F to 550°F).	Not LOX or fuel resistant. Moderate corrosion resistance.	Heat cure; 163°C (325°F), 1.0 hr. spray, dip or brush application.
PT-17* TECHLUBE	Microfine MoS_2, resin binder	Solid film for rolling and sliding surfaces. Usage similar to PT-14 with higher load limits 41.37 x 10^7 N/m^2 (60,000 psi). Temperature range, -184°C to 260°C (-300°F to 500°F).	Same as PT-14.	Heat cure; 163°C (325°F), 1.0 hr. spray, dip or brush application.
PT-24* TECLUBE	Microfine MoS_2 and silicon resin binder	Solid film lube for sliding and rolling surfaces under moderate loads 13.79 x 10^7 N/m^2 (20,000 psi) and high temperature; -73°C to 538°C (-100°F to 1000°F)	Similar to PT-14.	Heat cured; 249°C (480°F), 1.0 hr. spray, dip or brush application.
PT-26M* TECHLUBE	Microfine MoS_2 and multipolymer resin binder	General use lube, load capacity 20.69 x 10^7 N/m^2 (30,000 psi); temperature range, -54°C to 260°C (-65°F to 500°F).	Similar to PT-14.	Air-dry; spray, dip or brush application.
PT-101 (MOLY SPRAY)	MoS_2, proprietary carrier and drying agent	General use; machine tools, plastics, food handling equipment, mechanisms, etc. For extreme temperature and pressures 275.8 x 10^7 N/m^2 (400,000 psi); temperature range, -54°C to 260°C (-65°F to 500°F).	Similar to PT-14.	Air-dry. Aerosol spray.

* PT-14 prime coat provides good corrosion resistance for Techlube lubes.

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SANDSTROM PRODUCTS COMPANY				
MANUFACTURER'S DESIGNATION	CHEMICAL COMPOSITION	SUGGESTED USES	COMPATIBILITY LOX, FUEL, ETC.	NOTES
Sandstrom 9A (MIL-L-461010 A)	MoS_2, antimony trioxide and dibasic lead phosphate in epoxy-phenolic resin	Dry film lube for sliding surfaces, high temperature and loads. Provides wear-life and corrosion protection. Ordnance equipment, threads, pipe fittings, high pressure seals, helicopter shafts, etc. May be used in vacuum as film, has no outgassing at 1.33×10^{-6} N/m^2 (10^{-6} torr).	Resistant to "LOX," jet fuel, rocket fuels, acids, alkalis and degreasers.	Heat cured dry film lube. Cure at 149°C (300°F), 2 hr. Paint-like lube, can be brushed, dipped or spray application. Operating range -196°C to 260°C (-320°F to 500°F).
Sandstrom 26A (RIAPD 703) (MIL-L-46147MR)	MoS_2 and corrosion-inhibiting pigments, lacquer-like air-dry binder (epoxy)	Properties are similar to 9A. This material is good as a field or touchup coating where heat cure film cannot be applied. Will stand loads exceeding 6.895×10^8 (100,000 psi).	Same as 9A.	Air-dry film. Operating range, -196°C to 149°C (-320°F to 300°F).
Sandstrom Hi-T-650	MoS_2 and corrosion-inhibiting pigment, modified silicone binder (contains no graphite)	Developed for high temperature use 260°C-399°C (500°F-750°F). Provide long wear-life at temperature above limits of 9A or 26A. Lubricating properties and load capacity are similar to 26A.	Not for fluids or fuels.	Air-dry 72 hr. Can be cured at 249°C (480°F) for 1.0 hr. This film is based on Air Force Material Laboratory development of AFSL-41.

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AIV - MANUFACTURER SUPPLIED APPLICATION DATA
FOR SOLID LUBRICANTS

ACHESON COLLOIDS COMPANY

PRODUCT NAME OR CODE / PROPERTIES	RELEASE COATING No. 7	DAG® 154	DAG® 244	DAG® 250
SPECIFICATION	-	-	-	-
COMPOSITION: Lubricant	TFE Telomer	Graphite	MoS_2 and Additives	MoS_2/Graphite
Binder/Carrier	"Freon"	Isopropyl Alcohol 20% Solid	Resin Bond	Phenolic Resin 42% Solid
APPLICATION: Brush	No	X	X	-
Dip or Tumble	No	X	X	-
Spray	Aerosol Can	Best	X	X
CURE CYCLE: Air Dry	2-3 Min.	Yes	Air Dry, 10 mm. &	-
Heat	No	No	149°C (300°F)	149°C (300°F)
Temp/Time		-	for 1.0 Hr.	1.0 Hr.
COMPATIBILITY: LOX	-	Batch Test	-	-
Oxygen (gas)	-	Batch Test	-	-
Rocket Fuel	-	-	-	-
Jet Fuel	-	-	L	X
Hydrocarbon	L	L	L	X
Solvents	L	L	L	X
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high)	260°C (500°F)	204°C (400°F)[1]	-	204°C (400°F)
(low)	-	-	-	-
Vacuum: (high)	-	-	-	-
(low)	-	-	-	-
LOAD CAPACITY: Force	Low Load and Low Speed	M - G Varying with film life	15,568 N (3,500 lb)	M
Test Method	-	-	Falex	-
WEAR-LIFE: Load	L	2,802 N (630 lb)	4,448 N (1,000 lb.)	2,802 N (630 lb.)
Test Method	-	Alpha Tester	Falex	Alpha Tester
Time	-	1.0 Hr.	190 Min.	150 Hr.
Test Cond.	-	7.9 m. (26 ft/min)	Ambient	7.9 m. (26 ft/min)
FRICTION COEF.; STATIC, Air	L	L	L	L
Vacuum	-	-	-	-
DYNAMIC, Air	0.09 to 0.19	0.15	L	0.01
Vacuum	-	-	-	-
ELECT. CONDUCTIVITY	-	Good	-	-
CORROSION RESISTANCE	L	L	G	G
VACUUM WT. LOSS, N/m^2	-	-	-	-
mg/cm^2	-	-	-	-
Vacuum	-	-	-	-
Time	-	-	-	-
USES ON: Rubber & Plastics	X	X	-	-
Wood, Leather, Fibers	X	-	-	-
Glass & Ceramics	X	X	X	X
Metals	X	X	X	X
TYPICAL USES: Gen. Purp. Lub.	L	X	X	X
Fretting, Galling, Seizing	X	X	X	X
Cams, Gears, Slide Surf.	X	X	X	X
Rolling Surf.	L	X	X	X
Release Agent or Metal Work	X	-	-	-
NOTES: V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Nonstaining and nonoily dispersion. At temperature above 299°C (570°F) toxic and irritating vapors will be released.	Conductive lubricants have excellent film forming properties. Have many uses including assembly and "run-in" of O.E.M. items.[1] May be used to 454°C (850°F) for limited periods.	Meets load and endurance specifications for MIL-L-8937, and has good corrosion resistance. Applications include aircraft fasteners, brake screw assemblies, vending machines.	Good adhesion, hard film. Good corrosion properties. Moderate load and speed applications.

PROPERTIES / PRODUCT NAME OR CODE	EMRALON® 317	EMRALON® 319	EMRALON® 320 (EMRALON® 321)* (EMRALON® 322)*	EMRALON® 327
SPECIFICATION	-	-	-	-
COMPOSITION: Lubricant	PTFE Coating	PTFE Coating	PTFE Coating	PTFE Coating
Binder/Carrier	Polyurethane Resin	Silicone Resin	Thermoplastic Resin	Thermoplastic Resin
APPLICATION: Brush	X	L	-	-
Dip or Tumble	X	L	L	-
Spray	Best	Best	Best	Aerosol
CURE CYCLE: Air Dry	5-6 Hr., or 66°-93°C(150°-200°F)	10 Min., then 204°C (400°F)	2 Hr.	2 Hr.
Heat			-	-
Temp/Time	30 Min. (high humidity)	30 Min.	-	-
COMPATIBILITY: LOX	-	-	-	-
Oxygen (gas)	-	-	-	-
Rocket Fuel	-	-	-	-
Jet Fuel	L	X	X	L
Hydrocarbon	X	X	X	L
Solvents	L	-	L	-
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high)	121°C (250°F)	204°C (400°F)	82°C (180°F)	82°C (180°F)
(low)	-	-	-	-
Vacuum: (high)	-	-	-	-
(low)	-	-	-	-
LOAD CAPACITY: Force	G	M	V.G.	V.G.
Test Method	-	-	-	-
WEAR-LIFE: Load	2,802 N (630 lb.)	2,802 N (630 lb.)	2,802 N (630 lb.)	2,802 N (630 lb.)
Test Method	Hartman Tester	Hartman Tester	Hartman Tester	Hartman Tester
Time	E	M	V.G.	V.G.
Test Cond.	7.9 m.(26 ft/min)	7.9 m.(26 ft/min)	7.9 m.(26 ft/min)	7.9 m.(26 ft/min)
FRICTION COEF.; STATIC, Air	0.08-0.10	0.05-0.07	0.05-0.07	0.06-0.09
Vacuum	-	-	-	-
DYNAMIC, Air	-	-	-	-
Vacuum	-	-	-	-
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	M	Fair	M	M
VACUUM WT. LOSS, N/m^2	-	-	-	-
mg/cm^2	-	-	-	-
Vacuum	-	-	-	-
Time	-	-	-	-
USES: ON Rubber & Plastics	X	-	L	X
Wood, Leather, Fibers	X	-	X	X
Glass & Ceramics	X	X	X	X
Metals	X	X	X	X
TYPICAL USES: Gen. Purp. Lub.	X	X	X	X
Fretting, Galling, Seizing	X	X	X	X
Cams, Gears, Slide Surf.	X	X	X	X
Rolling Surf.	X	X	X	X
Release Agent or Metal Work	X	X	X	X
NOTES: E - Excellent; V.G. - Very Good; G - Good; M - Medium; P - Poor; L - Limited or Low; - - No Data or Not Applicable; X - Satisfactory	Excellent adhesion, low friction, corrosion resistance and good release properties. Abrasion resistance better than pure PTFE. Limited use at 149°C (300°F)	Solid film lub. has low friction, good heat resistance, abrasion, and release properties. Limited use to 232°C (450°F). Toxic vapors are released above 204°C (400°F).	Excellent adhesion, low friction, good corrosion and release properties. Limited use to 116°C (240°F). * 321 and 323 are equivalent to 320. 321 may be used on food equipment.	Similar to 320 but in aerosol container. Has low friction and good release properties. Limited use to 116°C (240°F)

ACHESON COLLOIDS COMPANY

PRODUCT NAME OR CODE / PROPERTIES	MOLYDAG® 254	EMRALON® 310 (EMRALON® 311)* (EMRALON® 313)*	EMRALON® 312	EMRALON® 315 (EMRALON® 316)*
SPECIFICATION	-	-	-	-
COMPOSITION: Lubricant Binder/Carrier	MoS_2/Lub. Pigments Thermoset Resin (55% solid)	PTFE Coating Phenolic Resin	PTFE Coating Acrylic Resin	PTFE Coating Epoxy Resin
APPLICATION: Brush Dip or Tumble Spray	X X X	- - X	- - X	- - X
CURE CYCLE: Air Dry Heat Temp/Time	10 Min. and 232°C (450°F)(1) 30 Min.	- 149°C (300°F) 60 Min.	- 149°C (300°F) 30 Min.	- 177°C (350°F) 1.0 Hr.
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - - X X X	- - - L X L	- - - M X M	- - - L X X
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	135°C (275°F) - - -	177°C (350°F)** -34°C (-30°F) - -	-149°C (300°F) -34°C (-30°F) - -	177°C (350°F) -34°C (-30°F) - -
LOAD CAPACITY: Force Test Method	15,568 N (3,500 lb.) Falex	V.G. -	G -	G -
WEAR-LIFE: Load Test Method Time Test Cond.	4,448N(1,000 lb.) Falex 350 Min. 7.9 m.(26 ft/min)	2,802 N (630 lb.) Hartman Tester E 7.9 m.(26 ft/min)	2,802 N (630 lb.) Hartman Tester V.G. 7.9 m.(26 ft/min)	2,802 N (630 lb.) Alpha Tester 0-1.0 Hr. 7.9 m.(26 ft/min)
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L - 0.123 -	0.05-0.07 - - -	0.08-0.10 - - -	0.07-0.10 - - -
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	G	V.G.	G	V.G.
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	- - - -	- - - -
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	L - X X	L L X X	X X X X	- L X X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X L L	X X X - L	X X X - L
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Meets load and endurance limits for MIL-L-8937A. (1) May be cured at 149°C (300°F) but properties are reduced. Limited use to 149°C (300°F).	Good adhesion friction, corrosion and release properties. * 311 and 313 are equivalent to 310. ** Limited use at 204°C (400°F). 311 may be used in food processing equipment.	Excellent adhesion, low friction and good release properties. for flexible substrate. Limited use to 177°C (350°F).	Excellent adhesion, low friction and heat and chemical resistance. Limited use to 204°C (400°F). * Emralon® 316 is equivalent to 315.

PROPERTIES \ PRODUCT NAME OR CODE	EMRALON® 328	EMRALON® 329	EMRALON® 330	
SPECIFICATION	-	-	-	
COMPOSITION: Lubricant Binder/Carrier	PTFE Coating Thermoplastic	PTFE Coating Thermoplastic Resin	PTFE Coating Resin	
APPLICATION: Brush Dip or Tumble Spray	X X X	X X X	- X Best	
CURE CYCLE: Air Dry Heat Temp/Time	2 Hr. - -	2 Hr. - -	2-5 min., and 149°C (300°F) 1.0 Hr.	
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - L L L -	- - L L L -	- - L X X L	
RADIATION PROPERTIES	-	-	-	
OUTGASSING PROPERTIES	-	-	-	
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	82°C (180°F) - - -	82°C (180°F) - - -	135°C (275°F) - - -	
LOAD CAPACITY: Force Test Method	V.G. -	V.G. -	G -	
WEAR-LIFE: Load Test Method Time Test Cond.	2,802 N (630 lb.) Hartman Tester V.G. 7.9 m. (26 ft/min)	2,802 N (630 lb.) Hartman Tester V.G. 7.9 m. (26 ft/min)	- - - -	
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	0.06-0.09 - - -	0.06-0.09 - - -	0.05-0.07 - - -	
ELECT. CONDUCTIVITY	-	-	-	
CORROSION RESISTANCE	M	M	G	
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	- - - -	
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	X X X X	X X X X	L L X X	
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X X	X X X X X	X X X X -	
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Low friction and release properties. Moderate chemical resistance(i.e., H_2SO_4 and NaOH). Limited use to 116°C (240°F)	Low friction and release properties. Moderate chemical resistance. May be applied by electrostatic spray. Limited use to 116°C (240°F).	Excellent adhesion, and low friction. Resists corrosion, abrasion, flex and impact. Limited use to 149°C (300°F). Used on gears, shafts, slides bearings, etc.	

PROPERTIES \ PRODUCT NAME OR CODE	VAC KOTE 21207	VAC KOTE BPS 18.07		
SPECIFICATION	-	-		
COMPOSITION: Lubricant Binder/Carrier	MoS_2 None	MoS_2 and Solids, Organic Binder, Xylene/Alcohol		
APPLICATION: Brush Dip or Tumble Spray	Proprietary Process	X X X		
CURE CYCLE: Air Dry Heat Temp/Time	None - -	- 149°C (300°F) 1.0 Hr.		
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - - X X X	- - - X X X		
RADIATION PROPERTIES	-	-		
OUTGASSING PROPERTIES	-	-		
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	149°C (300°F) -268°C (-450°F) 371°C (700°F) -268°C (-450°F)	288°C (550°F) -184°C (-300°F) 288°C (550°F) -184°C (-300°F)		
LOAD CAPACITY: Force Test Method	> 1.379 N/m^2 (> 200,000 psi) -	> 0.689 N/m^2 (> 100,000 psi) -		
WEAR-LIFE: Load Test Method Time Test Cond.	7.12 N (1.6 lb.) 0.013 m.(0.5 in.) Ball on flat; 300 Min. Inert Gas	4,448 N(1,000 lb.) Falex 340 Min. Room Temperature		
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	0.10 to 0.20 - 0.03 to 0.10 -	0.10 to 0.20 - 0.04 to 0.10 -		
ELECT. CONDUCTIVITY	-	-		
CORROSION RESISTANCE	-	L		
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- 10^{-12} < 1.33 x 10^{-4} N/m^2 (< 10^{-6} torr)/Sec.	- 10^{-11} at < 1.33 x 10^{-4} N/m^2 (< 10^{-6} torr)/sec		
USES: Rubber & Plastics ON Wood, Leather, Fibers Glass & Ceramics Metals	- - L X	- - L X		
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	L L X - -	X X X - -		
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	For rolling contact bearings operating in vacuum. Ball bearings, ball bushing, Inst. gears, hard vacuum and space.	High loading surface in air and vacuum. Sliding surfaces, low-high loads and low-high temperature.		

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PROPERTIES / PRODUCT NAME OR CODE	MOLYLUBE AR®	MOLYLUBE SR®	MOLYLUBE N®	MOLYLUBE® SPRAYCOTE
SPECIFICATION	-	MIL-L-8937	MIL-L-81329	-
COMPOSITION: Lubricant Binder/Carrier	MoS_2 Resin	MoS_2 Resin	MoS_2 Inorganic-Organic Resin (30% Solid)	MoS_2 Solvent and Bonding Agents
APPLICATION: Brush Dip or Tumble Spray	X X X	X X X	X - X	X X X
CURE CYCLE: Air Dry Heat Temp/Time	6 Hr. - -	- 177°C (350°F)* 30 Min.	1.0 Hr. 79°C (175°F) 30 Min.	X - -
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	No Reaction No Reaction No Reaction X X X	- - X X X X	Batch Test X - X X L	- - - - L L
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	399°C (750°F) -73°C (-100°F) - -	399°C (750°F) -73°C (-100°F) - -	760°C (1400°F) -184°C (-300°F) - -	- - - -
LOAD CAPACITY: Force Test Method	E -	16,680N (3,750 lb.) Falex	V.G. -	E -
WEAR-LIFE: Load Test Method Time Test Cond.	M - M -	4,448N (1,000 lb.) Falex 535 Min. Ambient	V.G. - - -	G - - -
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	- - 0.035 to 0.04 -	- - 0.025 -	L L L L	L L - -
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	G	G	G	E
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	- - 1.33×10^{-7} N/m^2 (10^{-9} mm.Hg) G	- - - -
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	- L X X	- - X X	- - X X	X X X X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X -	X X X X -	X X X - -
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Odorless and non-flammable. Excellent for extreme temp. and pressure and for high speed speeds. Resistant to chemicals. Will not pick up dust, dirt or lint.	Hard chemical resistant film. Excellent antigalling and seizing properties. Long wear-life. *Maximum properties are obtained by cure at 204°C (400°F) for 60 min.	Very tough film, good adhesion for extreme temperature ranges and vacuum. Maximum properties are obtained by cure at 82°C (180°F) for 2 hr. then 260°C (500°F) for 2 hr.	General use for machinery, tools and sliding surfaces. Contains no resinous or lacquer binders.

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DOW CORNING CORPORATION

PRODUCT NAME OR CODE / PROPERTIES	DOW CORNING® 3402	DOW CORNING® 1-3943	MOLYKOTE® 557 (Dow Corning 1-3944)*	
SPECIFICATION	MIL-L-23398B	AFSL-41	-	
COMPOSITION: Lubricant	Solid Lube Blend and Additives,	Solid Lube Blend (incl. MoS_2)	Clear Wax-Like Lube, in Fast Evaporating Solvent	
Binder/Carrier	Organic Resin	Silicone Resin		
APPLICATION: Brush	X	X	X	
Dip or Tumble	X	X	X	
Spray	X, Aerosol	X	X, Aerosol	
CURE CYCLE: Air Dry	Air Dry, 24 Hr. or	Air Dry, 75 Hr.	Very Fast	
Heat	204°C (400°F)	-	-	
Temp/Time	1.0 Hr.	-	-	
COMPATIBILITY: LOX	-	-	-	
Oxygen (gas)	-	-	-	
Rocket Fuel	L	-	-	
Jet Fuel	X	P	-	
Hydrocarbon	X	P	-	
Solvents	X	P	-	
RADIATION PROPERTIES	-	-	-	
OUTGASSING PROPERTIES	-	-	-	
USABLE TEMP. Air: (high)	316°C (600°F)	427°C (800°F)	60°C (140°F)	
(low)	-198°C (-325°F)	-198°C (-325°F)	-18°C (0°F)	
Vacuum: (high)	-	-	-	
(low)	-	-	-	
LOAD CAPACITY: Force	13,344 N (3,000 lb.)	17,792 N (4,000 lb.)	4,448 N (1,000 lb.)	
Test Method	Falex	Falex	Falex	
WEAR-LIFE: Load	2,802 N (630 lb.)	2,802 N (630 lb.)	2,802 N (630 lb.)	
Test Method	LFW-1	LFW-1	LFW-1	
Time	694 Min.	1,111 Min.	62 Min.	
Test Cond.	7.9 m. (26 ft/min)	7.9 m. (26 ft/min)	7.9 m. (26 ft/min)	
FRICTION COEF.; STATIC, Air	L	L	L	
Vacuum	-	-	-	
DYNAMIC, Air	L	L	L	
Vacuum	-	-	-	
ELECT. CONDUCTIVITY	-	-	-	
CORROSION RESISTANCE	V.G.	P	P	
VACUUM WT. LOSS, N/m^2	-	-	-	
mg/cm^2	-	-	-	
Vacuum	-	-	-	
Time	-	-	-	
USES: ON Rubber & Plastics	-	-	L	
Wood, Leather, Fibers	L	L	L	
Glass & Ceramics	X	X	L	
Metals	X	X	X	
TYPICAL USES: Gen. Purp. Lub.	X	L	-	
Fretting, Galling, Seizing	X	X	X	
Cams, Gears, Slide Surf.	X	X	L	
Rolling Surf.	L	L	L	
Release Agent or Metal Work	-	X	X	
NOTES: E - Excellent; V.G. - Very Good; G - Good; M - Medium; P - Poor; L - Limited or Low; - - No Data or Not Applicable; X - Satisfactory	Extreme pressure lubricant, primarily for corrosion protection. Also approved under following specifications. RIA-PD-703 RIA-PD-42 MIL-L-40147	Developed as an antifretting lube for Titanium (Air Force Laboratory development)	Clear, colorless, nontoxic lube. Excellent for alum. and other cold metal working. *Similar to 557, except has Freon carrier instead chlorothene used on plastics.	

DOW CORNING CORPORATION

PROPERTIES \ PRODUCT NAME OR CODE	MOLYKOTE® 321 (Dow-Corning 1-3931)*	MOLYKOTE® 523	MOLYKOTE® M-8800	DOW CORNING® 3400A
SPECIFICATION	-	-	-	MIL-L-46010A
COMPOSITION: Lubricant Binder/Carrier	Solid Lube Blend (incl. MoS_2) Inorganic Binder	Modified TFE Inorganic Binder	Solid Lube Blend (incl. MoS_2) Resin Binder	Solid Lube Blend Plus Additives Thermoset Resin
APPLICATION: Brush	X	X	X	X
Dip or Tumble	X	X	X	X
Spray	X, Aerosol	X, Aerosol	X, Aerosol	X
CURE CYCLE: Air Dry	Air Dry, 5 Min.	Air Dry, 5 Min.	Air Dry, 4 Hr.	-
Heat	-	-	or 121°C (250°F)	204°C (400°F)
Temp/Time	-	-	5 Min.	1.0 Hr.
COMPATIBILITY: LOX	X	-	-	-
Oxygen (gas)	X	-	-	-
Rocket Fuel	X	L	L	L
Jet Fuel	X	X	X	X
Hydrocarbon	X	X	X	X
Solvents	X	X	X	X
RADIATION PROPERTIES	G	-	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high)	649°C (1200°F)	260°C (500°F)	232°C (450°F)	482°C (900°F)
(low)	-198°C (-325°F)	-198°C (-325°F)	-198°C (-325°F)	-198°C (-325°F)
Vacuum: (high)	-	-	-	-
(low)	-	-	-	-
LOAD CAPACITY: Force	1,120 N (2,500 lb.)	2,224 N (500 lb.)	12,232N (2,750 lb.)	17,347N (3,900 lb.)
Test Method	Falex	Falex	Falex	Falex
WEAR-LIFE: Load	2,802 N (630 lb.)	2,802 N (630 lb.)	2,802 N (630 lb.)	2,802 N (630 lb.)
Test Method	LFW-1	LFW-1	LFW-1	LFW-1
Time	4,861 Min.	69 Min.	4,681 Min.	1,389 Min.
Test Cond.	7.9 m. (26 ft/min)	7.9 m. (26 ft/min)	7.9 m. (26 ft/min)	7.9 m. (26 ft/min)
FRICTION COEF.; STATIC, Air	-	-	-	-
Vacuum	-	-	-	-
DYNAMIC, Air	0.03-0.07	0.02-0.04	< 0.10	< 0.10
Vacuum	-	-	-	-
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	G	G	V.G.	Best
VACUUM WT. LOSS, N/m^2	-	-	-	-
mg/cm^2	-	-	-	-
Vacuum	G	-	-	-
Time	-	-	-	-
USES ON: Rubber & Plastics	X	X	-	-
Wood, Leather, Fibers	L	X	L	-
Glass & Ceramics	X	X	X	X
Metals	X	X	X	X
TYPICAL USES: Gen. Purp. Lub.	X	X	X	X
Fretting, Galling, Seizing	X	X	X	X
Cams, Gears, Slide Surf.	X	X	X	X
Rolling Surf.	L	L	X	X
Release Agent or Metal Work	L	X	-	-
NOTES: E - Excellent; V.G. - Very Good; G - Good; M - Medium; P - Poor; L - Limited or Low; - - No Date or Not Applicable; X - Satisfactory	Extreme environment film. Excel. on alum. Soft film best on nonphosphated surfaces. *Similar to 321, very thin film, 2.54×10^{-6} m. (0.001 m.) - Experimental	Chemically inert film having wide temperature properties. Intended for low load conditions.	Good chemical resistance. For general use, has wear-life similar to heat cured films.	Best corrosion resistance of all films. Extreme pressure also. Intend to protect bearing surfaces. Has high friction during wear-in.

PRODUCT NAME OR CODE / PROPERTIES	MOLYKOTE® SPRAY-KOTE	MOLYKOTE® X-15	MOLYKOTE® M-88	MOLYKOTE® 106 (273)* (Dow Corning 1-3923)**
SPECIFICATION	-	MIL-L-81329	-	MIL-L-8937
COMPOSITION: Lubricant Binder/Carrier	MoS_2 Powder (Microsize) Organic Binder	MoS_2, Graphite Sodium Silicate Binder	Solid Lube Blend (incl. MoS_2) Resin Binder	Solid Lube Blend (incl. MoS_2) Thermoset Resin
APPLICATION: Brush	-	X	X	X
Dip or Tumble	X	X	X	X
Spray	Aerosol*	X	X	X
CURE CYCLE: Air Dry	Air Dry - 10 Min.	2 Hr. at R.T.	Air Dry - 24 Hr.	-
Heat	-	or 82°C (180°F)	-	149°C (300°F)
Temp/Time	-	for 2 Hr. & 149°C (300°F) 2 Hr.	-	1.0 Hr.
COMPATIBILITY: LOX	-	X	-	-
Oxygen (gas)	-	X	-	-
Rocket Fuel	-	X	-	-
Jet Fuel	L	X	L	X
Hydrocarbon	L	X	L	X
Solvents	-	L	L	X
RADIATION PROPERTIES (Gamma)	-	5×10^9	-	-
OUTGASSING PROPERTIES	-	-	-	Unacceptable
USABLE TEMP. Air: (high)	399°C (750°F)	649°C (1200°F)	232°C (450°F)	232°C (450°F)
(low)	-73°C (-100°F)	-198°C (-325°F)	-198°C (-325°F)	-198°C (-325°F)
Vacuum: (high)	-	-	-	-
(low)	-	-	-	-
LOAD CAPACITY: Force	9,990N (2,250 lb.)	9,990N (2,250 lb.)	6,672N (1,500 lb.)	15,568N (3,500 lb.)
Test Method	Falex	Falex	Falex	Falex
WEAR-LIFE: Load	2,802N (630 lb.)	2,802N (630 lb.)	2,802N (630 lb.)	2,802N (630 lb.)
Test Method	LFW-1	LFW-1	LFW-1	LFW-1
Time	625 Min.	834 Min.	1,389 Min.	6,250 Min.
Test Cond.	7.9 m. (26 ft/min)	7.9 m. (26 ft/min)	7.9 m. (26 ft/min)	7.9 m. (26 ft/min)
FRICTION COEF.; STATIC, Air	L	M	L	L
Vacuum	L	M	L	L
DYNAMIC, Air	0.03-0.07	M	0.03-0.07	0.03-0.07
Vacuum	-	M	L	L
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	L	G	Fair	G
VACUUM WT. LOSS, N/m^2	-	-	-	-
mg/cm^2		-	-	-
Vacuum	-	-	-	-
Time	-	-	-	-
USES ON: Rubber & Plastics	L	-	X	-
Wood, Leather, Fibers	X	-	X	-
Glass & Ceramics	X	X	X	X
Metals	X	X	X	X
TYPICAL USES: Gen. Purp. Lub.	X	X	X	X
Fretting, Galling, Seizing	X	X	X	X
Cams, Gears, Slide Surf.	X	X	X	X
Rolling Surf.	L	X	L	L
Release Agent or Metal Work	X	-	-	-
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Easy to apply MoS_2 powder, adheres to most surfaces, highly polished and not degreased. For low loads. Film is soft and washes-off with most fluids.	Extreme environments; temp. vacuum, radiation LOX compt. Relatively high friction and break-in is difficult.	Easy to apply. Low friction, and for good wear and extreme loads. Good for polished surfaces. Easiest film to apply.	Good adhesion, and chemical resistance. Most widely used. Dow heat cured bonded film. *Similar to 106 but contains no graphite. **1-3923 (Experimental) is an alternate for 106.

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DRILUBE COMPANY

PRODUCT NAME OR CODE / PROPERTIES	DRILUBE 867	DRILUBE 868	DRILUBE 869	DRILUBE 870
SPECIFICATION	-	-	-	-
COMPOSITION: Lubricant Binder/Carrier	Molybdenum Diselenide Silicate Binder	Molybdenum Tellurium Silicate Binder	Tungsten Diselenide Silicate Binder	Tungsten Tellurium Silicate Binder
APPLICATION: Brush Dip or Tumble Spray	L L Best	L L Best	L L Best	L L Best
CURE CYCLE: Air Dry Heat Temp/Time	Air Dry, 1.0 Hr. 82°C (180°F),2 Hr. 204°C (400°F) for 4 Hr.	Air Dry, 1.0 Hr. 82°C (180°F) 2 Hr. 204°C (400°F) for 4 Hr.	Air Dry, 1.0 Hr. 82°C (180°F) 2 Hr. 204°C (400°F) for 4 Hr.	Air Dry, 1.0 Hr. 82°C (180°F) 2 Hr. 204°C (400°F) for 4 Hr.
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	X X - X X X	X X - X X X	X X - X X X	X X - X X X
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	538°C (1000°F) Cryogenic 1093°C (2000°F) Cryogenic	> 538°C (>1000°F) Cryogenic > 1093°C (>2000°F) Cryogenic	> 538°C (>1000°F) Cryogenic > 1093°C (>2000°F) Cryogenic	> 538°C (> 1000°F) Cryogenic > 1093°C (>2000°F) Cryogenic
LOAD CAPACITY: Force Test Method	V.G. -	V.G. -	V.G. -	V.G. -
WEAR-LIFE: Load Test Method Time Test Cond.	- - P (G) R.T. (Hi-T)	- - P (G) R.T. (Hi-T)	- - P (G) R.T. (Hi-T)	- - P (G) R.T. (Hi-T)
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L L L L	L L L L	L L L L	L L L L
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	Fair	Fair	Fair	Fair
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	- - - -	- - - -
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	- - X X	- - X X	- - X X	- - X X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X L -	X X X L -	X X X L -	X X X L -
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Very expensive film for extreme temperature and hard vacuum. LOX compt. Special purpose applications.	Very expensive film for very high temperature and vacuum. LOX compt. Special applications.	Very expensive film for very high temperature and vacuum. LOX compt. and for special purposes.	Very expensive film for very high temperature and vacuum. LOX compt. and for special purposes.

DRILUBE COMPANY

PROPERTIES \ PRODUCT NAME OR CODE	DRILUBE 1A	DRILUBE 701 & 702	DRILUBE 805	DRILUBE 861
SPECIFICATION	MIL-L-8739	-	-	-
COMPOSITION: Lubricant Binder/Carrier	MoS_2, Graphite Epoxy Blend	$MoS_2/SrCrO_4$ Phosphoric Binder	MoS_2* Silicate Binder	Tungsten Disulfide Silicate Binder
APPLICATION: Brush Dip or Tumble Spray	X X Best	X (702) X (701) X (701)	- - X	L L Best
CURE CYCLE: Air Dry Heat Temp/Time	- 191°C (375°F) 1.0 Hr.	- 204°C (400°F) 1.0 Hr.	Air Dry, 1.0 Hr. 82°C (180°F) 2 Hr. 204°C (400°F) for 4 Hr.	Air Dry, 1.0 Hr. 82°C (180°F) 2 Hr. 204°C (400°F) for 4 Hr.
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - - X X 	X X - X X X	X* X* - X X L	X X - X X X
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	Acceptable	-	-	-
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	260°C (500°F) - 184°C (-300°F) 316°C (600°F) -184°C (-300°F)	371°C (700°F) -240°C (-400°F) 649°C (1200°F) -240°C (-400°F)	371°C (700°F) -240°C (-400°F) 649°C (1200°F -240°C (-400°F)	399°C (750°F) Cryogenic 760°C (1400°F) Cryogenic
LOAD CAPACITY: Force Test Method	G -	G -	V.G. -	V.G. -
WEAR-LIFE: Load Test Method Time Test Cond.	- - E (G) Air (Vacuum)	- - P (G) R.T. (Hi-T)	- - P (G) R.T. (Hi-T)	- - P (G) R.T. (Hi-T)
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L L L L	L L L L	L L L L	L L L L
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	G	Fair	Fair	Fair
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	- - - -	- - - -
USES: Rubber & Plastics ON Wood, Leather, Fibers Glass & Ceramics Metals	- - X X	- - X X	- - X X	- - X X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X -	X X X L -	X X X L -
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Excellent wear-life. Resist heat or pressure. Used on aircraft, electronic and industrial items. Drilube 1B is similar but cured at 177°C (350°F). Not to MIL-L-8739	LOX compt. Good high temp. wear-life and other properties. Binder is acidic and contact with skin should be avoided. R.T. properties are fair.	High load film, for high temp. LOX compt. *Graphite is sometimes added, BOS is then not LOX compt.	High cost lube for use at high temp. and vacuum LOX compt. Special purpose applications.

PROPERTIES / PRODUCT NAME OR CODE	DRI-SLIDE®			
SPECIFICATION	-			
COMPOSITION: Lubricant Binder/Carrier	MoS_2, Volatile carrier and anti-corrosion additive			
APPLICATION: Brush Dip or Tumble Spray	X L L			
CURE CYCLE: Air Dry Heat Temp/Time	X - -			
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - - X X L			
RADIATION PROPERTIES	-			
OUTGASSING PROPERTIES	-			
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	399°C (750°F) -101°C (-150°F) 538°C (1000°F) -101°C (-150°F)			
LOAD CAPACITY: Force Test Method	6.9×10^8 N/m^2 (100,000 psi) Falex			
WEAR-LIFE: Load Test Method Time Test Cond.	High - G -			
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L L L L			
ELECT. CONDUCTIVITY	-			
CORROSION RESISTANCE	G			
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -			
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	X X X X			
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X X			
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Good for general lubrication of machinery, tools, office machinery, gears, sliding surfaces, etc. Contains a rust inhibitor.			

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PROPERTIES / PRODUCT NAME OR CODE	LUBE-LOK 66-C	LUBE-LOK 2006	LUBE-LOK 2306 (2396)*	LUBE-LOK 2406
SPECIFICATION	-	-	NASA-1367	-
COMPOSITION: Lubricant Binder/Carrier	MoS_2/Graphite Phenolic Resin	MoS_2/Graphite Silicone-Formaldehyde	MoS_2 Sodium Silicate	Graphite Polyimide
APPLICATION: Brush Dip or Tumble Spray	X X X	L - Best	L L X	L L X
CURE CYCLE: Air Dry Heat Temp/Time	- 191°C (375°F) 1.0 Hr.	- 260°C (500°F) 2 Hr.	- 82°C(180°F) 2 Hr. + 204°C(400°F) 2 Hr.	- 82°C(180°F) 2 Hr.+ 204°C(400°F) 2 Hr.
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	Batch Test Batch Test Batch Test X X X	- - - X L L	X X X X X L	X X X X X L
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	371°C (700°F) -184°C (-300°F) - -	454°C (850°F) -184°C (-300°F) - -	426°C (800°F) -251°C (-420°F) - -	454°C (850°F) -251°C(-420°F) - -
LOAD CAPACITY: Force Test Method	High -	Good -	L -	L -
WEAR-LIFE: Load Test Method Time Test Cond.	5.52×10^8 N/m^2 (80,000 psi) Macmilian, 70 Hr. 7.9 m.(26 ft/min)	2,802 N(630 lb.) Macmillan 160 Hr 7.9 m.(26 ft/min)	M - - -	M - - -
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	- - 0.04 -	0.10-0.13 - 0.025-0.05 -	L - L -	L - L -
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	G	L	-	-
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	- - - -	- - - -
USES: Rubber & Plastics ON Wood, Leather, Fibers Glass & Ceramics Metals	- - X X	- - X X	- - X X	- - X X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	L X X X -	L X I X -	L X L X -
NOTES: E - Excellent V.G - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	General purpose solid film lube for heavy duty and good wear-life. Third in volume usage among electro-film heat cured solid lubes.	For high loads and excellent wear-life and high temp. Jet and missile applications. Fourth in volume usage among electro-film heat cured solid lubes.	Rolling element bearings and high vacuum. * 2396 contains MoS_2/graphite and has properties similar to 2306, and meets MIL-L-81329 and temp. to 454°C (850°F)	General use at high temp. Lube properties not as good as MoS_2 films. May be used with N_2O_4, N_2H_2, and aerozene.

PRODUCT NAME OR CODE / PROPERTIES	LUBRI-BOND M	LUBRI-BOND N	ELECTRO-MOLY Grade 1	ELECTRO-GRAPH
SPECIFICATION	-	WS 9004	MIL-M-7866	MIL-G-6711
COMPOSITION: Lubricant	MoS_2	$NBSe_2$	MoS_2	Graphite
Binder/Carrier	Freon	Phenolic	Powder	Powder
APPLICATION: Brush	L	L	L	L
Dip or Tumble	L	L	L	L
Spray	Best	Best	-	-
CURE CYCLE: Air Dry	Air Dry	Air Dry	-	-
Heat	-	-	-	-
Temp/Time	-	-	-	-
COMPATIBILITY: LOX	Batch Test	-	X	X
Oxygen (gas)	Batch Test	-	X	X
Rocket Fuel	Batch Test	-	X	X
Jet Fuel	X	X	X	X
Hydrocarbon	X	X	X	X
Solvents	X	X	X	X
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high)	371°C (700°F)	371°C (700°F)	371°C (700°F)	1093°C(2000°F)
(low)	-73°C (-100°F)	-73°C (-100°F)	-196°C (-320°F)	-196°C (-320°F)
Vacuum: (high)	-	-	-	-
(low)	-	-	-	-
LOAD CAPACITY: Force	G	M	G	G
Test Method	-	-	-	-
WEAR-LIFE: Load	L	L	M	M
Test Method	-	-	-	-
Time	-	-	-	-
Test Cond.	-	-	-	-
FRICTION COEF.; STATIC, Air	L	L	L	L
Vacuum	-	-	-	-
DYNAMIC, Air	L	L	L	L
Vacuum	-	-		-
ELECT. CONDUCTIVITY	-	G	-	G
CORROSION RESISTANCE	M	L	X	X
VACUUM WT. LOSS, N/m^2	-	-		-
mg/cm^2	-	-	-	-
Vacuum	-	-	-	-
Time	-	-	-	-
USES ON: Rubber & Plastics	X	X	X	X
Wood, Leather, Fibers	X	X	X	X
Glass & Ceramics	X	X	X	X
Metals	X	X	X	X
TYPICAL USES: Gen. Purp. Lub.	X	X	X	X
Fretting, Galling, Seizing	X	X	X	X
Cams, Gears, Slide Surf.	L	L	X	X
Rolling Surf.	L	L	X	X
Release Agent or Metal Work	X	-	X	X
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Touch-up film, high loads and short wear-life. Third in volume usage of electrofilm air dry solid lubes.	High temp., air dry solid film lube. Second in volume usage of electrofilm air dry films.	Granular form of solid film lube, for burnishing or rub-on application. Fourth in volume usage of electrofilm air dry solid lubes.	Granular solid film for rub-on or burnishing. High temp. use.

PROPERTIES \ PRODUCT NAME OR CODE	LUBE-LOK 2606 (2696)	LUBE-LOK 4306 (4396)*	LUBE-LOK 5396 (5306)*	LUBRI-BOND A
SPECIFICATION	-	NASA-A-D-66A	MIL-L-8937*	MIL-L-23398
COMPOSITION: Lubricant	WS_2	MoS_2	MoS_2	MoS_2-Graphite
Binder/Carrier	Sodium Silicate	Phenolic	Phenolic	Phenolic
APPLICATION: Brush	L	X	X	-
Dip or Tumble	L	X	X	-
Spray	X	X	X	*, Aerosol
CURE CYCLE: Air Dry	-	-	-	Air Dry, 30 Min.
Heat Temp/Time	82°C(180°F)2 Hr. + 204°C(400°F)2 Hr.	191°C (375°F) 1-1/2 Hr.	-149°C (300°F) 1.0 Hr.	-
COMPATIBILITY: LOX	X	-	-	-
Oxygen (gas)	X	-	-	-
Rocket Fuel	X	-	-	-
Jet Fuel	X	X	X	X
Hydrocarbon	X	X	X	X
Solvents	L	X	X	X
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high)	510°C (950°F)	316°C (600°F)	316°C (600°F)	316°C (600°F)
(low)	-184°C (-300°F)	-184°C (-300°F)	-184°C (-300°F)	-184°C (-300°F)
Vacuum: (high)	-	-	-	-
(low)	-	-	-	-
LOAD CAPACITY: Force	G	G	E	M
Test Method	-	-	-	-
WEAR-LIFE: Load	M	2,802 N (630 lb.)	E	G
Test Method	-	Macmillan	-	-
Time	-	60 Hr.	G	-
Test Cond.	-	7.9 m.(26 ft/min)	-	-
FRICTION COEF.; STATIC, Air	L	L	0.02	0.08
Vacuum	-	-	-	-
DYNAMIC, Air	L	L	0.02-0.04	0.03-0.06
Vacuum	-	-	-	-
ELECT. CONDUCTIVITY	-	-	-	L
CORROSION RESISTANCE	-	X	X	X
VACUUM WT. LOSS, N/m^2	-	-	-	-
mg/cm^2	-	-	-	-
Vacuum	-	-	-	-
Time	-	-	-	-
USES ON: Rubber & Plastics	-	L	-	X
Wood, Leather, Fibers	-	L	-	X
Glass & Ceramics	X	X	X	X
Metals	X	X	X	X
TYPICAL USES: Gen. Purp. Lub.	X	X	X	X
Fretting, Galling, Seizing	X	X	X	X
Cams, Gears, Slide Surf.	X	X	X	X
Rolling Surf.	X	X	X	X
Release Agent or Metal Work	-	-	-	-
NOTES: E - Excellent; V.G. - Very Good; G - Good; M - Medium; P - Poor; L - Limited or Low; - - No Data or Not Applicable; X - Satisfactory	Low friction film for high temp., less oxid., than MoS_2. * 2696 also contains graphite and has properties similar to 2606.	Heavy-duty film for use where graphite is not allowed. * 4396 is similar but has small quanity of graphite. Second in volume usage among electrofilm heat cured solid lubes.	Low temp. cure. Good chem. resist * 5306 is similar and meet MIL-L-8937A Spec. 5396 is most used electrofilm heat cured solid film, 5306 is very close second.	Most widely used air dry electrofilm solid film lube. General use for light-medium load and wear-life.

PRODUCT NAME OR CODE / PROPERTIES	LUBRI-BOND HT			
SPECIFICATION	AFSL-41			
COMPOSITION: Lubricant Binder/Carrier	MoS_2-Sb_2O_3 Silicone			
APPLICATION: Brush Dip or Tumble Spray	X - -			
CURE CYCLE: Air Dry Heat Temp/Time	Air Dry 72 Hr.			
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - - X X X			
RADIATION PROPERTIES	-			
OUTGASSING PROPERTIES	-			
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	399°C (750°F) -196°C (-320°F) - -			
LOAD CAPACITY: Force Test Method	> 11,120 N (> 2,500 lb.) Falex			
WEAR-LIFE: Load Test Method Time Test Cond.	2,802 N(630 lb.) Macmillan > 380 Hr. 7.9 m.(26 ft/min)			
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L - 0.02 -			
ELECT. CONDUCTIVITY	-			
CORROSION RESISTANCE	G			
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -			
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	X X X X			
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X X			
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Air dry solid film lube developed by Air Force Laboratory. Good for use on titanium.			

PRODUCT NAME OR CODE / PROPERTIES	EVERLUBE 620	EVERLUBE 626	EVERLUBE 811	INLOX 44 & 88
SPECIFICATION	SEE NOTE*	-	MIL-L-81329*	
COMPOSITION: Lubricant Binder/Carrier	MoS_2 Phenolic Resin (modified)	MoS_2 Phenolic Resin (modified)	MoS_2/Graphite Sodium Silicate	MoS_2/Graphite Phosphoric Acid Binder
APPLICATION: Brush Dip or Tumble Spray	X X Best	X X Best	X X Best	- - X
CURE CYCLE: Air Dry Heat Temp/Time	- 191°C (375°F) 1.0 Hr.	- 149°C (350°F) 1.0 Hr.	Air-Dry, 15 mm. + 66°C(150°F)2 Hr. and 204°C (400°F) 2 Hr.	Air-Dry, 30 Min. then 191°C (375°F) 1-1/2 Hr.
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - L X X X	- - L X X X	X X L X X X	X X X X X X
RADIATION PROPERTIES	-	-	V.G.	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	260°C (500°F) -221°C (-365°F) - -	260°C (500°F) -221°C (-365°F) - -	649°C (1200°F) -240°C (-400°F) X X	371°C (700°F) -240°C (-400°F) X X
LOAD CAPACITY: Force Test Method	> 6.9×10^8 N/m^2 (> 100,000 psi) Falex	- -	10.4×10^8 N/m^2 (> 150,000 psi) -	- -
WEAR-LIFE: Load Test Method Time Test Cond.	2,224 N (500 lb.) Falex > 70 Hr. 7.9 m.(26 ft/min)	- - - -	G - - -	- - - -
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	< 0.10 - < 0.10 -	L - L -	L L L L	L L L L
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	G	G	G	G
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	Negl. - 1.33×10^{-7} N/m^2 -	Negl. - - -
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	X X X X	X X X X	- - X X	- - X X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X -	X X X X -	X X X X -
NOTES: E E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	*MIL-L-8937 Good adhesion, antiseize and fluid resistance.	For general use, excellent fluid resistance. Good antifriction film but not as good as 620.	E.P. and high temp., radiation and vacuum. *Also to NASA Spec. MSFC-106, -143, -238. KSC-F-124 and NASA 1008939 and many indust. spec.	Antiseize coating threads, fittings, couplings, etc. Primarily for cryogenic use. *Also NASA 1367

EVERLUBE CORPORATION

PRODUCT NAME OR CODE / PROPERTIES	ECOALUBE® 642	EVERLOX 16, 17, 18	EVERLUBE 967	PERMA-SLIK®
SPECIFICATION	MIL-L-46010		-	MIL-L-46009
APPLICATION: Brush Dip or Tumble Spray	MoS_2 - Metallic Oxide, Corrosion Inhibitor Resin Binder	MoS_2 and Chemical Bonded	MoS_2, Corrosion Resist. Buffering Compound, H.T. Binder	MoS_2/Graphite Volatile Resin
APPLICATION: Brush Dip or Tumble Spray	X X Best	- - X	- - X	X X Best
CURE CYCLE: Air Dry Heat Temp/Time	- 204°C (400°F) 1.0 Hr.	- 149°C (300°F) 1.0 Hr.	Air-dry, 15 min. and 66°C (150°F) 1.0 Hr. and 302°C (575°F), 1.0 Hr.	X - -
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - - X X L	X X X X X L	- - L X X X	- - L X X L
RADIATION PROPERTIES	-	G	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	260°C (500°F) -221°C (-365°F) - -	X Cryogenic X X	399°C (750°F) -184°C (-300°F) - -	260°C (500°F) -184°C (-300°F) - -
LOAD CAPACITY: Force Test Method	8,896N (2,000 lb.) Falex	G -	6.9×10^8 N/m^2 (100,000 psi) -	G -
WEAR-LIFE: Load Test Method Time Test Cond.	4,448N (1,000 lb.) Falex > 450 mm. Ambient	G - - -	G - - -	M - - -
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L - L -	- - - -	L - L -	L - L -
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	V.G.	G	G	L
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	X X X X	- - - -	- - - -
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	- - X X	L* L* X X	- - X X	X X X X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X -	X X X X -	X X X X -
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Good corrosion resist., reduce wear, prevent galling. Good adhesion and fluid resist., for parts in storage or adverse environment.	Antiseize and antigalling film For cryogenic use *EVERLOX-17, 18 an air-drying form of this film.	Special high temp film. For use by aircraft, spacecraft, missile and general industry.	Prevent wear and reduce galling. General application, office, shop, machinery. --bearings, gears, valves, nuts, fittings, etc.

PROPERTIES / PRODUCT NAME OR CODE	FEL-PRO C-200	FEL-PRO C-300	FEL-PRO C-640	FEL-PRO C-651A
SPECIFICATION	-	-	MIL-L-8937	MIL-L-46010A
COMPOSITION: Lubricant Binder/Carrier	MoS_2 blended lube Organic Binder	MoS_2 blended lube Semi-inorganic Binder	MoS_2 blended lube Epoxy-phenolic Binder	MoS_2 blended lube (no Graphite) Epoxy-phenolic Binder
APPLICATION: Brush Dip or Tumble Spray	X X X	X - X	X X X	X X X
CURE CYCLE: Air Dry Heat Temp/Time	- 260°C (500°F) 1/2 Hr.	Air-dry - 24 Hr. - -	- 163°C (325°F) 1.0 Hr.	- 204°C (400°F) 1.0 Hr.
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - - X X L	- - - X X L	- - - X X X	- - - X X X
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	-	Acceptable	-	-
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	816°C (1500°F) -54°C (-65°F) 1316°C (2400°F) -54°C (-65°F)	649°C (1200°F) -54°C (-65°F) X X	288°C (550°F) -73°C (-100°F) - -	316°C (600°F) -73°C (-100°F) - -
LOAD CAPACITY: Force Test Method	15,568 N (3,500 lb.) Falex	16,680 N (3,750 lb.) Falex	11,120 N (2,500 lb.) Falex	7,780 N (1,750 lb.) Falex
WEAR-LIFE: Load Test Method Time Test Cond.	4,448 N (1,000 lb.) Falex > 150 Min. Ambient	4,448 N (1,000 lb.) Falex 164 Min. Ambient	4,448 N (1,000 lb.) Falex 180 Min. Ambient	4,448 N (1,000 lb.) Falex 300 Min. Ambient
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L - 0.07 - 0.11 -	L - 0.07 - 0.11 -	L - 0.07 - 0.11 -	L - < 0.07 -
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	G	M	V.G.	V.G.
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - G -	- - G -	- - - -	- - - -
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	- - X X	L L X X	- - X X	- - X X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X -	X X X X -	X X X X X
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Extreme loads, temp. and med. speed. Widely used on aircraft and missiles--on steels, Mag., Titanium, Alum., etc.	Used on aero., automotive and general machinery. Improved properties are obtained by heat cure at 260°C (500°F) for 1/2 hr.	Very good solvent and corrosion resistance, for wide variety of materials and products.	Excellent wear characteristics corrosion resist. and release properties.

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GENERAL MAGNAPLATE CORPORATION

PRODUCT NAME OR CODE / PROPERTIES	TURFRAM®	NEDOX®	CANADIZING®	HI-T-LUBE®
SPECIFICATION	-	-	-	-
COMPOSITION: Lubricant Binder/Carrier	TFE impregnated on Al_2O_3 surface (proprietary)	PTFE & nickel film, proprietary process	Proprietary film for Titanium (see note)	Proprietary film and process
APPLICATION: Brush		-	-	-
Dip or Tumble	-	-	-	-
Spray	See Note	See Note	See Note	See Note
CURE CYCLE: Air Dry	See Note	See Note	See Note	See Note
Heat	-	-	-	-
Temp/Time	-	-	-	-
COMPATIBILITY: LOX	-	-	-	Impact Sensitive
Oxygen (gas)	-	-	-	L
Rocket Fuel	-	-	-	No
Jet Fuel	X	X	X	X
Hydrocarbon	X	X	X	X
Solvents	X	X	L	X
RADIATION PROPERTIES	X	X	X	X
OUTGASSING PROPERTIES	X	X	X	X
USABLE TEMP. Air: (high)	316°C (600°F)	260°C (500°F)	371°C (700°F)	538°C (1000°F)
(low)	-268°C (-450°F)	cryogenic	cryogenic	-54°C (-65°F)
Vacuum: (high)	-	-	-	-
(low)	-	-	-	-
LOAD CAPACITY: Force	V.G.	-	-	High
Test Method	-	-	-	-
WEAR-LIFE: Load	V.G.	G	G	High
Test Method	-	-	-	-
Time	-	-	G	G
Test Cond.	-	-	-	-
FRICTION COEF.; STATIC, Air	0.04 - 0.08	0.04	-	< 0.10
Vacuum	L	-	-	-
DYNAMIC, Air	0.04 - 0.08	0.04	-	< 0.10
Vacuum	L	-	-	-
ELECT. CONDUCTIVITY	Non-Cond.	-	X	-
CORROSION RESISTANCE	V.G.	V.G.	V.G.	-
VACUUM WT. LOSS, N/m^2	Nil	-	-	-
mg/cm^2	-	-	-	-
Vacuum	10^{-6}	-	-	-
Time	-	-	-	-
USES: Rubber & Plastics	-	-	-	-
ON Wood, Leather, Fibers	-	-	-	-
Glass & Ceramics	-	-	-	
Metals	Aluminum	Ferrous & Copper	Titanium	X
TYPICAL USES: Gen. Purp. Lub.	X	X	X	X
Fretting, Galling, Seizing	X	X	X	X
Cams, Gears, Slide Surf.	X	X	X	X
Rolling Surf.	X	X	X	X
Release Agent or Metal Work	X	X	X	-
NOTES: E - Excellent; V.G. - Very Good; G - Good; M - Medium; P - Poor; L - Limited or Low; - - No Data or Not Applicable; X - Satisfactory	Electrochemical bonded film for alum. Hard film good wear and abrasion prop. corrosion resist. low friction and good heat transfer.	Electrochemical bonded film of hard-nickel & PTFE. Resist abrasion and corrosion. Proprietary process and heat treat. film for steel and copper alloys.	Electrochemical bonded hard film impregnated with TFE, MoS_2 or Graphite. Resist corrosion and has high fatigue-strength bearing prop.	Good adhesion, and heat cond. Proprietary film and cure cycle. Primarily for high strength and high temp.

GENERAL MAGNAPLATE CORPORATION

PRODUCT NAME OR CODE / PROPERTIES	MAGNALUBE® D-801	MAGNALUBE® D-4821	MAGNALUBE D-5261	
SPECIFICATION	-	-	-	
COMPOSITION: Lubricant Binder/Carrier	MoS_2 Modified Resin Binder	Matrix solid film (MoS_2), Metallic Bond	Solid film and volatile binder.	
APPLICATION: Brush Dip or Tumble Spray	X X Best	X X Best	X X Best	
CURE CYCLE: Air Dry Heat Temp/Time	- 191°C (375°F) 1.0 Hr.	- 177°C (350°F) 1.0 Hr.	Air-dry - 30 Min. - -	
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - - X X X	- - - X X X	- - - X X L	
RADIATION PROPERTIES	-	-	-	
OUTGASSING PROPERTIES	-	-	-	
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	260°C (500°F) -54°C (-65°F) - -	- - - -	260°C (500°F) -54°C (-65°F) - -	
LOAD CAPACITY: Force Test Method	G -	G -	M -	
WEAR-LIFE: Load Test Method Time Test Cond.	E - - -	2802 N (630 lb.) MacMillan > 80 Hr. Ambient	- - - -	
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L - 0.012 - 0.03 -	- - 0.025 - 0.030 -	- - 0.10 - 0.40 -	
ELECT. CONDUCTIVITY	-	-	-	
CORROSION RESISTANCE	G	G	L	
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	- - - -	
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	- - L X	- - L X	- L X X	
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X -	X X X X -	
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Durable solid film for many uses. Prevents galling, seizing, cold welding, fretting corrosion, etc. For severe environments.	High bearing pressure, temp. and high speed applications. Good for severe environments.	Good adhesion and low friction, for part assembly and general use. Reduces wear, seizing and galling.	

H. A. HENDERSON COMPANY

PROPERTIES \ PRODUCT NAME OR CODE	HENDERLUBE 402A	HENDERLUBE 413	HENDERLUBE 462A	
SPECIFICATION	MIL-L-8937A	MIL-L-46010A	-	
COMPOSITION: Lubricant Binder/Carrier	MoS_2, Corrosion Inhibitor and Modified Phenolic	MoS_2, Corrosion Inhibitor and Modified Epoxy	MoS_2, Corrosion Inhibitor and Modified Silicone	
APPLICATION: Brush Dip or Tumble Spray	X X X	X X Best	X X Best	
CURE CYCLE: Air Dry Heat Temp/Time	- 163°C (325°F) 30 Min.	- 177°C (350°F) 1.0 Hr.	- 232°C (450°F) 2 Hr.	
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	No L L X X L	No* L L X X L	- - - - - -	
RADIATION PROPERTIES	-	-	-	
OUTGASSING PROPERTIES	-	-	-	
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	260°C (500°F) -73°C (-100°F) - -	260°C (500°F) -73°C (-100°F) - -	454°C (850°F) -73°C (-100°F) 593°C (1100°F) -73°C (-100°F)	
LOAD CAPACITY: Force Test Method	13,789 N (3,100 lb.) Falex	10,008 N (2,250 lb.) Falex	- -	
WEAR-LIFE: Load Test Method Time Test Cond.	4,448 N(1,000 lb.) Falex > 330 Min. Ambient	4,448 N(1,000 lb.) Falex > 600 Min. Ambient	- - - -	
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L - 0.035 to 0.040 -	L - L -	L - L -	
ELECT. CONDUCTIVITY	-	-	-	
CORROSION RESISTANCE	E	V.G.	M	
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	- - - -	
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	- - X X	- - X X	- - X X	
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X -	X X X X -	
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Sliding and rolling surfaces at high loads and speeds. Reduces galling, wear, and fretting. Fungus resist.per MIL-E-5272A. Most widely used Henderson dry film.	* 6 hr. at 204°C (400°F) cure reported compt. to LOX. Properties similar to 402A. Second most used Henderson dry film, 402A and 413 account for 90 to 95% usage.	For medium high temperature above 260°C (500°F). Not in presence of solvents, hydrocarbons, etc. Short periods of time above 454°C (850°F).	

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PRODUCT NAME OR CODE / PROPERTIES	SURF-KOTE® LO-1800	SURF-KOTE® M-2036	SURF-KOTE® M-2049	SURF-KOTE® A-2178A
SPECIFICATION	-	-	MIL-L-46010	-
COMPOSITION: Lubricant Binder/Carrier	MoS_2 Blended Lube, Inorganic Binder	MoS_2 and Other Solid Lube, Polyimide Binder	MoS_2 and Other Solid Lube, Resin Binder	MoS_2 and Other Solid Lubes, Organic Resin
APPLICATION: Brush Dip or Tumble Spray	L - X	- - X	X X Best	X X X and Aerosol
CURE CYCLE: Air Dry Heat Temp/Time	- 149°C (300°F) 2.0 Hr.	- 93°C (200°F) 1.0 Hr. and 288°C (550°F) 1.0 Hr.	Air-Dry, 30 Min. and 204°C (400°F) 1.0 Hr.	Air-Dry, 72 Hr. - -
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	No Reaction No Reaction L X X L	- - - X X L	- - L X X L	- - L X X L
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	399°C (750°F) X X X	399°C (750°F) X X X	260°C (500°F) -54°C (-65°F) - -	316°C (600°F) X - -
LOAD CAPACITY: Force Test Method	G -	G -	- -	- -
WEAR-LIFE: Load Test Method Time Test Cond.	G - G -	G - G -	4,448 N(1,000 lb.) Falex 500 Min. Ambient	- - - -
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L L L L	L L L L	L - L -	L - L -
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	G	Very Poor	E	-
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	- - - -	- - - -
USES: Rubber & Plastics ON Wood, Leather, Fibers Glass & Ceramics Metals	- - X X	- - X X	- - X X	L X X X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X -	X X X X -	X X X X -
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Date or Not Applicable X - Satisfactory	Nonflammable. For use in a vacuum or liquid oxygen systems.	Contains MoS_2 and other pigment lubes, but no graphite. Has maximum endurance life to 399°C (750°F). Fair adhesion.	Contains no graphite or powdered metals. Excellent corrosion and adhesion properties. Contains compounds and solvents that may be toxic, do not breath fumes or use on food equipment.	Similar to AFSL-41 but has better adhesion and fluid resistance. May be heat cured at 249°C (480°F) for 30 min. May be used on titanium.

PRODUCT NAME OR CODE / PROPERTIES	SURF-KOTE® H-108	SURF-KOTE® 359 (360*)	SURF-KOTE® M-1284	SURF-KOTE® A-1625
SPECIFICATION	-	-	MIL-L-8937	MIL-L-23398B
COMPOSITION: Lubricant Binder/Carrier	MoS_2 Modified Resin Binder	TFE Phenolic Resin	MoS_2 Metal Matrix Resin	Pigment Lube Resin Bond
APPLICATION: Brush Dip or Tumble Spray	X X Best	- - X	X X X	- - Aerosol
CURE CYCLE: Air Dry Heat Temp/Time	Air-Dry, 45 Sec. 191°C (375°F) 1.0 Hr.	- 149°C (300°F) 1.0 Hr.	- 177°C (350°F) 1.0 Hr.	Air-Dry, 30 Min. - -
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - L X X X	- - X X X L	- - - X X L	- - - X X L
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	260°C (500°F) L - -	177°C (350°F) L - -	> 427°C (> 800°F) X - -	260°C (500°F) -54°C (-65°F) - -
LOAD CAPACITY: Force Test Method	M -	M -	V.G. -	M -
WEAR-LIFE: Load Test Method Time Test Cond.	2,802 N (603 lb.) MacMillan V.G. - P Ambient - Hi-T	- - - -	2,802 N (630 lb.) MacMillan > 80 Hr. 7.9 m.(26 ft/min)	- - - -
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	- - 0.012 to 0.03 -	L - L -	L - 0.003 -	L - L -
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	L	V.G.	V.G.	L
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	- - - -	- - - -
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	- - X X	X X X X	- - X X	L L X X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X X	X X X X -	X X X X L
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Durable solid film, used for break-in lube on assembled parts, intermittent operated mechanisms. Eliminates galling, seizing, fretting corrosion, etc.	Excellent adhesion and corrosion protection, low cure. Toxic fumes released above 204°C (400°F). Flammable film as sprayed. *SURF-KOTE 360 similar, has alkyd resin.	For part assembly break-in lube, prevents fretting corrosion. Anti-seize film for extreme pressure and temperature.	Excellent adhesion, low friction, reduces wear, seizing and galling. Part assembly, machine shop, truck automotive, office and home use.

PRODUCT NAME OR CODE / PROPERTIES	Lubeco 905	Lubeco 2123	Lubeco 2023B	Lubeco M-390
SPECIFICATION	-	-	-	-
COMPOSITION: Lubricant Binder/Carrier	MoS_2, Graphite and Other Solid Lubes, Complex Chemical Binder	Blended Inorganic Solid Lubes	Blended Inorganic Solid Lubes	Blended Solid Lubes, Organic Binder
APPLICATION: Brush Dip or Tumble Spray	Electrodeposition (Applied by Lubeco Only)	Electrophoretic Binder System	Electrophoretic Binder System	X X X
CURE CYCLE: Air Dry Heat Temp/Time	- 204°C (400°F), Accelerates Plating	Nonrequired See Above - -	Nonrequired See Above - -	- - -
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - - - - -	No Reaction " " " " X X L	X X X X X L	- - - X X L
RADIATION PROPERTIES	X	-	-	-
OUTGASSING PROPERTIES	G	-	G	-
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	260°C (500°F) -269°C (-452°F) X X	427°C (800°F) -269°C (-452°F) - -	649°C (1200°F) 269°C (-452°F) - -	260°C (500°F) -213°C (-352°F) - -
LOAD CAPACITY: Force Test Method	G -	G -	G -	- -
WEAR-LIFE: Load Test Method Time Test Cond.	2802N (630 lb.) McMillan 164 Hr. Ambient	V.G. - - -	G - - -	E - - -
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	0.060 - 0.010 - 0.050 0.040	L L L L	L L L L	- - - -
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	M	M	M	-
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	$<$ 0.01% ($1x10^6$ Torr) -	- - Hard Vacuum X	- - Hard Vacuum -	- - - -
USES: Rubber & Plastics ON Wood, Leather, Fibers Glass & Ceramics Metals	- - - X	- - - X	- - - X	X X X X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X -	X X X X -	X X X X -
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Used on metal substrates. Parts that rub, side or roll at temp. up to 260°C (500°F) Ball, roller, and sleeve bearings, screws, nuts, gears, etc.	Nontoxic low friction lube; long wear-life, high loads, and low speeds at elevated temp. Adheres to all nonferrous metals without heat cure cycle.	Low friction at high temp., 816°C (1500°F) for short periods. Vacuum compatible nontoxic and good chemical resistance. Lubeco 2023B is similar, very inert to chem. attack.	All purpose dry film for general use. Gears, fasteners, slide surfaces, machinery, etc.

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MICROSEAL CORPORATION

PROPERTIES \ PRODUCT NAME OR CODE	Microseal 100-1	Microseal 200-1	Microseal 300-1	Microseal 200-23
SPECIFICATION	05-10626-A*	MIL-L-8937	-	-
COMPOSITION: Lubricant Binder/Carrier	Graphite, Inorganic Binder (Proprietary)	MoS_2, Inorganic Binder System (Proprietary)	Tungsten Disulfide inorganic Binder (Propriet.)	MoS_2 and High Temperature Binder
APPLICATION: Brush Dip or Tumble Spray	- - Impinged	- - Impinged	- - Impinged	- - Impinged
CURE CYCLE: Air Dry Heat Temp/Time	7 Days or 149°C (300°F) 2.0 Hr.	7 Days or 149°C (300°F) 2.0 Hr.	7 Days or 149°C (300°F) 2.0 Hr.	7 Days or 149°C (300°F) 2.0 Hr.
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	No Reaction No Reaction X X X X	- No Reaction X X X X	- No Reaction X X X X	- No Reaction X X X X
RADIATION PROPERTIES	G	G	G	G
OUTGASSING PROPERTIES	G	G	G	G
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	1093°C (2000°F) -253°C (-423°F) 1482°C (2700°F) -253°C (-423°F)	371°C (700°F) -198°C (-325°F) (1400°F) -198°C (-325°F)	482°C (900°F) -198°C (-325°F) 760°C (1400°F) -198°C (-325°F)	593°C (1100°F) -109°C (-165°F) 760°C (1400°F) -109°C (-165°F)
LOAD CAPACITY: Force Test Method	Limited By Base Material -	Limited By Base Material -	Limited By Base Material -	Limited By Base Material -
WEAR-LIFE: Load Test Method Time Test Cond.	3.45×10^7 N/m^2 (5,000 psi) - -	V.G. - - -	V.G. - - -	V.G. - - -
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L L 0.06-0.07 L	L L 0.02-0.06 L	L L 0.04 L	L L 0.02 L
ELECT. CONDUCTIVITY	X	-	-	-
CORROSION RESISTANCE	X	X	G	-
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	Negl. 1.33×10^{-7} N/m^2 (10^{-9} Torr) -	Negl. 1.33×10^{-7} N/m^2 (10^{-9} Torr) -	Negl. 1.33×10^{-7} N/m^2 (10^{-9} Torr) -	Negl. 1.33×10^{-7} N/m^2 (10^{-9} Torr) -
USES: Rubber & Plastics ON Wood, Leather, Fibers Glass & Ceramics Metals	L L X X	L L X X	- - X X	- - X X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X L	X X X X L	X X X X L	X X X X L
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	*USN/BW Spec. Nonflammable and nonexplosive. General purpose lube. For vacuum use.	Similar to 100-1 but has much lower friction due to MoS_2 in place of graphite. Higher loads than 100-1.	Tungsten disulfilm for specialized applications. Good chemical resistance.	Thicker film build-up than 200-1, good for extreme pressure. Used on tools shear-spinning and roll extrusion.

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PROPERTIES \ PRODUCT NAME OR CODE	MLF-5	MLF-9	MLR-2	MLR-66
SPECIFICATION	MSFC 502	MSFC 253	50M60434	-
COMPOSITION: Lubricant Binder/Carrier	MoS_2, Graphite Gold, Sodium Silicate, Water	MoS_2, Graphite Bismuth, Aluminum Phosphate water	MoS_2 + Sb_2O_3 Polymide	MoS_2 + Sb_2O_3 Polyphenylene Sulfide - Alcohol
APPLICATION: Brush Dip or Tumble Spray	X X X	X X X	X X X	- - X
CURE CYCLE: Air Dry Heat Temp/Time	Air Dry 30 Min. 82°C (180°F) 2 Hr and 149°C (300°F) 8 Hr.	Air Dry 30 Min. 82°C (180°F) 2 Hr and 149°C (300°F) 8 Hr.	Air Dry 30 Min. 149°C (300°F) 1.0 Hr. and 302°C (575°F) 1.0 Hr.	- 94°C (200°F) 1 Hr. 371°C (700°F) 1/2 Hr.
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	E X - - - -	E X - - - -	- G - X X -	- - - - - -
RADIATION PROPERTIES	Excellent	Excellent	Excellent	-
OUTGASSING PROPERTIES	Acceptable	-	Acceptable	-
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	538°C (1000°F) -73°C (-100°F) 538°C (1000°F) -73°C (-100°F)	371°C (700°F) -73°C (-100°F) 371°C (700°F) -73°C (-100°F)	260°C (500°F) X - -	427°C (800°F) R.T. - -
LOAD CAPACITY: Force Test Method	16,680 N(3,750 lb.) Falex	20,016N (4,500 lb.) Falex	20,01oN (4,500 lb.) Falex	20,016N (4,500 lb.) Falex
WEAR-LIFE: Load Test Method Time Test Cond.	4448 N (1,000 lb.) Falex 86 Min. 5.78 m.* (19 ft/min)	4448N (1,000 lb.) Falex 57 Min. 5.78 m.* (19 ft/min)	4448N (1,000 lb.) Falex 502 Min. 5.78 m.* (19 ft/min)	4448N (1,000 lb.) Falex > 600 Min. 5.78 m.* (19 ft/min)
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	0.29 - 0.15 -	0.30 - 0.20 -	0.23 - 0.18 -	- - 0.1 -
ELECT. CONDUCTIVITY	M	-	-	-
CORROSION RESISTANCE	No	-	-	-
VACUUM WT. LOSS, N/m^2 Vacuum Time	0.465 1.33×10^{-4} N/m^2 (10^{-6} torr) 528 Hr.	0.340 1.33×10^{-4} N/m^2 (10^{-6} torr) 528 Hr.	0.0775 1.33×10^{-4} N/m^2 (10^{-6} torr) 528 Hr.	- - - -
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	- - - X	- - - X	- - - X	- - - X
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X -	X X X X -	X X X - -
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Developed on a NASA contract for LOX compt. and high temp.	LOX compt. film good for high loads. Less expensive than MLF-5.	Do not use with other lubes. For severe wear-life cond. and elevated temp.	New film that has not yet been completely eval-uated.

* Meters per minute velocity.

PRODUCT NAME OR CODE / PROPERTIES	AFSL-28	AFSL-29	MEL-1*	
SPECIFICATION	-	-	-	
COMPOSITION: Lubricant Binder/Carrier	Calcium Fluoride Barium Fluoride Aluminum Phosphate	Calcium Fluoride Barium Fluoride Magnesium Fluoride Aluminum Phosphate	MoS_2	
APPLICATION: Brush Dip or Tumble Spray	- - X	- - X	DC Sputtering	
CURE CYCLE: Air Dry Heat Temp/Time	- 925°C (1,697°F) 1.0 Min.	- 750°C (1,382°F) 1.0 Min.	None	
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - - - - -	- - - - - -	- - - - - -	
RADIATION PROPERTIES	-	-	-	
OUTGASSING PROPERTIES	G	G	G	
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	816°C (1500°F) 21°C (70°F) > 538°C (>1000°F) 21°C (70°F)	649°C (1200°F) 21°C (70°F) - -	399°C (750°F) -73°C (-100°F) 399°C (750°F) -73°C (-100°F)	
LOAD CAPACITY: Force Test Method	V.G. -	V.G -	- -	
WEAR-LIFE: Load Test Method Time Test Cond.	V.G. - V.G. -	V.G. - V.G. -	4,448N (1,000 lb.) Falex > 40 Min. Ambient	
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	- - < 0.20 < 0.20	- - < 0.20 -	0.04 to 0.08 - 0.04 to 0.08 -	
ELECT. CONDUCTIVITY	-	-	-	
CORROSION RESISTANCE	-	-	L	
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	- - - -	
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	- - X X	- - X X	- - X X	
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X - -	X X X - -	L X X - -	
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	High temperature film. Developed for use at 1000°F in an air environment where it has its best friction and wear properties. Works best on Ni-based alloys Developed on Air Force contract.	High temperature film. Cures at lower temperature than AFSL-28. Has lower friction than AFSL-28 at temperatures below 1000°F. Developed on Air Force contract.	* Experimental sputtered film. Primarily used on ball bearing races and other applications requiring extremely thin films.	

PRODUCT NAME OR CODE / PROPERTIES	NPI-5 (MLF-5)	NPI-14	Dyna-Lube NPI-132	NPI-425 (MLR-2)
SPECIFICATION	MSFC-502	MIL-L-8937	-	NASA 50M60434
COMPOSITION: Lubricant Binder/Carrier	MoS_2, Graphite, Gold, Sodium Silicate and Water	Lubricative Pigments, Organic Resin	Silver and Refractory Metals, Electro-Plated	MoS_2 and Sb_2O_3 Polymide Resin
APPLICATION: Brush	X	X	-	X
Dip or Tumble	X	X	Electro-Deposited	X
Spray	Best	Best	-	Best
CURE CYCLE: Air Dry	Air Dry, 30 Min.	Air Dry - 15 Min.	-	Air Dry, 30 Min.
Heat Temp/Time	82°C(180°F), 2 Hr. and 149°C(300°F), 8 Hr.	149°C (300°F) 1.0 Hr.	- -	149°C(300°F), 1.0 Hr., 302°C (575°F), 1.0 Hr.
COMPATIBILITY: LOX	E	-	-	-
Oxygen (gas)	X	-	-	G
Rocket Fuel	-	-	-	-
Jet Fuel	-	X	X	X
Hydrocarbon	-	X	X	X
Solvents	-	L	-	-
RADIATION PROPERTIES	E	-	-	E
OUTGASSING PROPERTIES	Acceptable	-	-	Acceptable
USABLE TEMP. Air: (high)	538°C (1000°F)	G	760°C (1400°F)	260°C (500°F)
(low)	-73°C (-100°F)	G	-62°C (-80°F)	X
Vacuum: (high)	538°C (1000°F)	-	-	-
(low)	-73°C (-100°F)	-	-	-
LOAD CAPACITY: Force	16,680N (3,750 lb)	>11,120N (>2,500 lb.)	G	20,016N (4,500 lb.)
Test Method	Falex	Falex	-	Falex
WEAR-LIFE: Load	4,448N (1,000 lb.)	4,448N (1,000 lb.)	M	4,448N (1,000 lb)
Test Method	Falex	Falex	-	Falex
Time	86 Min.	> 3.0 Hr.	-	> 8.0 Hr.
Test Cond.	5.78 m.(19 ft/min)	Ambient	-	Ambient
FRICTION COEF.; STATIC, Air	0.29	L	0.40	0.23
Vacuum	-	-	-	-
DYNAMIC, Air	0.15	L	0.20-0.40	0.18
Vacuum	-	-	-	-
ELECT. CONDUCTIVITY	M	-	X	-
CORROSION RESISTANCE	No	-	F	-
VACUUM WT. LOSS, N/m^2	0.0465	-	-	-
mg/cm^2	$1.33 \times 10^{-4} N/m^2$	-	-	0.0775
Vacuum	(10^{-6} Torr)	-	-	$1.33 \times 10^{-4} N/m^2$
Time	528 Hr.	-	-	(10^{-6} Torr) 528 Hr.
USES ON: Rubber & Plastics	-	-	-	-
Wood, Leather, Fibers	-	-	-	-
Glass & Ceramics	-	-	-	-
Metals	X	X	X	X
TYPICAL USES: Gen. Purp. Lub.	X	X	X	X
Fretting, Galling, Seizing	X	X	X	X
Cams, Gears, Slide Surf.	X	X	X	X
Rolling Surf.	X	X	X	X
Release Agent or Metal Work	-	-	-	-
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Developed on a NASA contract for LOX compatibility and high loads.	For metal surfaces subject to mechanical wear, in fluids, extreme temperature and high loads.	May be used with conventional lubes as a back-up with grease friction coefficient is 0.02. Conduct elect. Good storage and heat properties.	Do not use with other lubes. For severe wear-life condition and elevated temperature.

PROPERTIES / PRODUCT NAME OR CODE	Vitro-Lube NPI-1220	MRIONITE NPI-2500*		
SPECIFICATION	-	-		
COMPOSITION: Lubricant Binder/Carrier	MoS_2, Graphite Ceramic Binder (Proprietary)	Calcium Fluoride, Barium Fluoride, Aluminum Phosphate		
APPLICATION: Brush Dip or Tumble Spray	- Dip, Preferred X	- - X		
CURE CYCLE: Air Dry Heat Temp/Time	- 524°C (975°F) 1.0 Min.	- 925°C (1697°F) 1.0 Min.		
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - - - - -	- - - - - -		
RADIATION PROPERTIES	-	-		
OUTGASSING PROPERTIES	-	G		
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	399°C (750°F) -134°C (-210°F) - -	816°C (1500°F) 21°C (70°F) 538°C (>100°F) 21°C (70°F)		
LOAD CAPACITY: Force Test Method	V.G. -	V.G. -		
WEAR-LIFE: Load Test Method Time Test Cond.	G - V.G. -	V.G. - V.G. -		
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	X - < 0.10 -	- - < 0.20 < 0.20		
ELECT. CONDUCTIVITY	-	-		
CORROSION RESISTANCE	-	-		
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -		
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	- - - X	- - X X		
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X L -	X X X - -		
NOTES: E - Excellent V.G.- Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Developed for XB-70. Highest friction at R.T., lowest at 288°C (550°F). Should be used dry, no fluid. May be applied to steel and titanium some aluminum alloys.	*AFSL-28 Developed for use at 1000°F in air environment. Where it has its best friction and wear properties. Work best on Ni-based alloys.		

PRODUCT NAME OR CODE / PROPERTIES	Poxylube 420 (330)*	Poxylube 500	Poxylube 750	
SPECIFICATION	-	MIL-L-8937	-	
COMPOSITION: Lubricant Binder/Carrier	MoS_2, Graphite, Solid Blend Thermoplastic	Blend MoS_2 Graphite and Solids, Epoxy Resin	Blend MoS_2 Graphite and Solids Epoxy Resin	
APPLICATION: Brush Dip or Tumble Spray	X X Best	X X Best	X X Best	
CURE CYCLE: Air Dry Heat Temp/Time	Air Dry, 24 Hr. - -	- 149°C (300°F) 1.0 Hr.	- 191°C (375°F) 1.0 Hr.	
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	- - - L L L	- - - X X L	- - - X X X	
RADIATION PROPERTIES	-	-	-	
OUTGASSING PROPERTIES	-	-	-	
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	79°C (175°F) -221°C (-350°F) - -	260°C (500°F) -212°C (-350°F) - -	288°C (550°F) 212°C (-350°F) - -	
LOAD CAPACITY: Force Test Method	G -	V.G. -	V.G. -	
WEAR-LIFE: Load Test Method Time Test Cond.	M - M -	G - G -	G - G -	
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L - L -	L - L -	L - L -	
ELECT. CONDUCTIVITY	-	-	-	
CORROSION RESISTANCE	[illegible]	L	Fair	
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - - -	- - - -	- - - -	
USES: Rubber & Plastics ON Wood, Leather, Fibers Glass & Ceramics Metals	L L X X	L L X X	L L X X	
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X -	X X X X -	
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	General use for antiseize and antigalling. For moderate temp., loads and wear. *330 is similar, has less resin and will air-dry in 30 min.	General use, good wear-life heat stability. Better adhesion and chemical resistance than air dry film. This film is most widely used poly-lube film. (Military)	Hard durable film for general use. Very good adhesion and wear life and good chemical resistance.	

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PROPERTIES \ PRODUCT NAME OR CODE	TECLUBE PT-14	TECLUBE PT-17	TECLUBE PT-24	TECLUBE PT-26M
SPECIFICATION		-	-	-
COMPOSITION: Lubricant Binder/Carrier	MoS_2, Graphite Epoxy Resin	MoS_2 and Resin Binder	MoS_2-Superfine, Silicone Resin	MoS2-Microfine, Polymer Resin (air dry)
APPLICATION: Brush	-	-	-	X
Dip or Tumble	X	X	X	X
Spray	X	X	X	X
CURE CYCLE: Air Dry	-	-	-	Air Dry, 1.0 Hr.
Heat Temp/Time	163°C (325°F) 1.0 Hr.	163°C (325°F) 1.0 Hr.	249°C (480°F) 1.0 Hr.	- -
COMPATIBILITY: LOX	-	-	-	-
Oxygen (gas)	-	-	-	-
Rocket Fuel	-	-	-	-
Jet Fuel	L	L	L	L
Hydrocarbon	L	L	L	L
Solvents	L	L	L	L
RADIATION PROPERTIES	-	-	-	-
OUTGASSING PROPERTIES	-	-	-	-
USABLE TEMP. Air: (high)	288°C (550°F)	260°C (500°F)	538°C (1000°F)	260°C (500°F)
(low)	-73°C (-100°F)	-184°C (-300°F)	-73°C (-100°F)	-54°C (-65°F)
Vacuum: (high)	-	-	-	-
(low)	-	-	-	-
LOAD CAPACITY: Force	2.76×10^8 N/m^2 (40,000 psi)	4.14×10^8 N/m^2 (60,000 psi)	1.38×10^8 N/m^2 (20,000 psi)	2.07×10^8 N/m^2 (30,000 psi)
Test Method	-	-	-	-
WEAR-LIFE: Load	M	M	L	M
Test Method	-	-	-	-
Time	G	G	G	G
Test Cond.	-	-	-	-
FRICTION COEF.; STATIC, Air	-	-	-	-
Vacuum	-	-	-	-
DYNAMIC, Air	0.025 - 0.075	0.025 - 0.075	0.025 - 0.075	0.025 - 0.075
Vacuum	-	-	-	-
ELECT. CONDUCTIVITY	-	-	-	-
CORROSION RESISTANCE	M	M	G	L
VACUUM WT. LOSS, N/m^2	-	-	-	-
mg/cm^2	-	-	-	-
Vacuum	-	-	-	-
Time	-	-	-	-
USES ON: Rubber & Plastics	L	L	L	X
Wood, Leather, Fibers	L	L	L	X
Glass & Ceramics	X	X	X	X
Metals	X	X	X	X
TYPICAL USES: Gen. Purp. Lub.	X	X	X	X
Fretting, Galling, Seizing	X	X	X	X
Cams, Gears, Slide Surf.	X	X	X	X
Rolling Surf.	X	X	X	X
Release Agent or Metal Work	-	-	-	-
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	General antisieze lube for sliding, rubbing or rolling surfaces, for most conditions. Not for high speed and high loads.	General lube similar to PT-14, but is for wider temperature range and higher loads.	General lube for high temperature and light loads. Low friction and good wear-life.	General lube similar to PT-24, but will air dry and is for lower temperature.

PRODUCT TECHNIQUES, INCORPORATED

PROPERTIES / PRODUCT NAME OR CODE	TECLUBE PT-101 (Moly Spray)	TECLUBE L-67		
SPECIFICATION	MIL-M-7866	-		
COMPOSITION: Lubricant Binder/Carrier	MoS_2 and Air Dry Resin	MoS_2 Blend Glass Binder		
APPLICATION: Brush Dip or Tumble Spray	- - X	- - X		
CURE CYCLE: Air Dry Heat Temp/Time	X - -	Air Dry, 30 Min., 82°C (180°F), 2 Hr. & 149°C (300°F), 2 Hr.		
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	Batch Test Batch Test - L X -	X X - X X -		
RADIATION PROPERTIES	G	-		
OUTGASSING PROPERTIES	-	-		
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	399°C (750°F) -73°C (-100°F) - -	1093°C (2000°F) -184°C (-300°F) X X		
LOAD CAPACITY: Force Test Method	G -	G -		
WEAR-LIFE: Load Test Method Time Test Cond.	G - G -	4,448 N (1,000 lb.) Falex > 80 Min. Ambient		
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L - L -	L L L L		
ELECT. CONDUCTIVITY	-	-		
CORROSION RESISTANCE	-	G		
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - 1.33×10^{-7} N/m^2 (10^{-9} Torr)	- - - -		
USES: ON Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	X X X X	- - X X		
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X X	X X X - -		
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Chemically inert, noncorrosive, noninflammable, nonconductive and nontoxic. General lube and antiseize. May be used at temperature -184°C (-300°F) and 538°C (1000°F) for short intervals.	Protective high temperature dry film. Nonflammable, for vacuum, LOX and high pressure Teclube PT-70 is similar.		

SANDSTROM PRODUCTS COMPANY

PROPERTIES / PRODUCT NAME OR CODE	SANDSTROM 9A	SANDSTROM 26A	SANDSTROM Hi-T 650*	
SPECIFICATION	MIL-L-46010A	MIL-L-46147(MR)*		
COMPOSITION: Lubricant Binder/Carrier	MoS_2, PbO_4 and Others, Epoxy-Phenolic Resin	MoS_2-inhibited Epoxy Resin	MoS_2, Corrosion Inhibitor Modified Silicone	
APPLICATION: Brush Dip or Tumble Spray	- X X	X X X, Aerosol	X X X	
CURE CYCLE: Air Dry Heat Temp/Time	Air Dry, 30 Min. 204°C (400°F) 1.0 Hr.	Air Dry, 16 Hr., or - -	Air Dry, 30 Min., (480°F) 1.0 Hr.	
COMPATIBILITY: LOX Oxygen (gas) Rocket Fuel Jet Fuel Hydrocarbon Solvents	X X X X X X	- - L X X X	- - L X X X	
RADIATION PROPERTIES	-	-	-	
OUTGASSING PROPERTIES	-	-	-	
USABLE TEMP. Air: (high) (low) Vacuum: (high) (low)	260°C (500°F) -196°C (-320°F) - -	149°C (300°F) -196°C (-320°F) - -	399°C (750°F) - - -	
LOAD CAPACITY: Force Test Method	12,232 N (2,750 lb.) Falex	11,120 N (2,500 lb.) Falex	13,340 N (3,000 lb.) Falex	
WEAR-LIFE: Load Test Method Time Test Cond.	4,448 N (1,000 lb.) Falex > 500 Min. 5.79 m (19 ft/sec)	4,448 N (1,000 lb.) Falex > 170 Min. 5.79 m (19 ft/sec)	4,448 N (1,000 lb.) Falex > 200 Min. 5.79 m (19 ft/sec)	
FRICTION COEF.; STATIC, Air Vacuum DYNAMIC, Air Vacuum	L L L L	L - L -	Very Low - Very Low -	
ELECT. CONDUCTIVITY	-	-	-	
CORROSION RESISTANCE	E	V.G.	G	
VACUUM WT. LOSS, N/m^2 mg/cm^2 Vacuum Time	- - $1.33x10^{-4}$ N/m2 (10^{-6} Torr)	- - - -	- - - -	
USES ON: Rubber & Plastics Wood, Leather, Fibers Glass & Ceramics Metals	- - X X	X X X X	- - X X	
TYPICAL USES: Gen. Purp. Lub. Fretting, Galling, Seizing Cams, Gears, Slide Surf. Rolling Surf. Release Agent or Metal Work	X X X X -	X X X X L	X X X X -	
NOTES: E - Excellent V.G. - Very Good G - Good M - Medium P - Poor L - Limited or Low - - No Data or Not Applicable X - Satisfactory	Prevents corrosion, galling, seizing and fretting. Chemical resistant and long wear-life. Contains no graphite.	*Formerly RIAPD-703. Easy to apply air dry film. Properties are similar to 9A, but lower limits. For use where heat cure cycle for 9A is not allowable. No graphite.	*Based on AFSL-41 properties similar to 9A and 26A but for higher temperature to 538°C (1000°F) for short periods. Contains no graphite.	

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AV - LABORATORY EVALUATIONS

- SOLID LUBRICATED GEARS

- COMPOSITE MATERIALS

The data presented in this section were collected from tests conducted on 22 solid lubricant films. All tests were conducted at Midwest Research Institute. All materials were applied in accordance with the manufacturer's direction, except that pretreatment of all metal substrates was by dry honing with 220 mesh Al_2O_3. There has been no attempt to rate the lubricants. Data presented provides a basis for comparing solid lubricant films.

Falex load carrying and wear-life test data are presented in Tables 1 and 2. Lightly loaded three-pellet wear-life test data are presented in Table 3. Electrical conductivity and vacuum weight loss data are included as Table 4. Table 5 presents data on the static and dynamic friction values for the films at -73°C (-100°F), 27°C (80°F), and 204°C (400°F). All of the films were also evaluated on journal bearing test equipment. Data for the journal bearing tests are presented in Table 6.

Tables 7, 8, 9, 10, and 11 and Figures 1, 2, and 3 contain test data obtained on solid film lubricated gears. Data presented in Tables 7, 8, and 9 and Figures 1, 2, and 3 are from laboratory tests whereas data shown in Tables 10 and 11 are from actual hardware tests conducted at the NASA Marshall Space Flight Center.

A large number of plastics, reinforced plastics and metal composites are available and used frequently in space applications. Many of the aforementioned materials are used as bearing or bearing components (separators, etc.). Tables 12, 13, and 14 contain a minimal amount of manufacturer supplied data on some of the most frequently used plastics, reinforced plastics and composite materials. More information can be obtained on the materials by contacting the manufacturers.

Laboratory test equipment used in evaluating the solid lubricants are described in Appendix A.

LIST OF TABLES

LIST OF FIGURES

TABLE 1

FALEX TESTS LOAD-CARRYING ABILITY

Test Method: Test Method Standard No. 791a, Method 3812
Test Condition: Ambient Temperature, AISI 4130 V-Block and Pin, R_c 40-45
Test Load: Load Increased in 1,112 N (250 lb.) Increments at 1.0 Min. Intervals Until Failure*

Solid Film	Average** Maximum Load - N (lb.)	Average** Maximum Torque - N m. (in-lb)	Average** Time to Failure (min.)
DAG 253	1.78×10^4 (4,000)	1.90 (16.8)	16
Drilube No. 1	2.00×10^4 (4,500)	1.16 (10.3)	23
Drilube 805	0.667×10^4 (1,500)	3.39 (30.0)	8
Electrofilm 2306	1.00×10^4 (2,250)	1.16 (10.3)	11
Electrofilm 5396	1.89×10^4 (4,250)	2.77 (24.5)	21
Lubribond "A"	1.00×10^4 (2,250)	2.26 (20.0)	12
Everlube 620	1.89×10^4 (4,250)	2.26 (20.0)	20
Everlube 811	1.89×10^4 (4,250)	2.88 (25.5)	18
Fel-Pro C-200	2.00×10^4 (4,500)	1.85 (16.4)	23
Fel-Pro C-300	2.00×10^4 (4,500)	2.15 (19.0)	22
MLR-2 (NPI 425) (VAC KOTE 18.07)	2.00×10^4 (4,500)	1.05 (9.3)	92
MLF-5	1.67×10^4 (3,750)	3.05 (27.0)	18
MLF-9	2.00×10^4 (4,500)	2.63 (23.3)	23
Molykote X-15	1.22×10^4 (2,750)	2.63 (23.7)	13
Molykote X-106	2.00×10^4 (2,500)	1.42 (12.6)	25
Molykote 321	1.11×10^4 (2,500)	2.00 (17.7)	12
NPI-14	1.78×10^4 (4,000)	2.91 (25.8)	19
Vitrolube	2.00×10^4 (4,500	3.39 (30.0)	372
Polylube No. 500	2.00×10^4 (4,500)	1.86 (16.5)	22
RIA No. 9	1.11×10^4 (2,500)	2.75 (24.3)	13
Surfkote M-1284	1.67×10^4 (3,750)	2.11 (18.7)	18
Surfkote A-1625	0.890×10^4 (2,000)	2.63 (23.3)	11

Notes: * Failure is indicated by inability of film to maintain load for 1.0 min., breaking of shear pin or sharp rise in torque of more than 0.791 N m. (7.0 in-lb).

** Average of 3 test runs.

TABLE 2

FALEX TESTS-WEAR-LIFE

Test Method: Federal Test Method Standard No. 791a, Method 3807
Test Condition: Ambient Temperature, AISI 4130 V-Block and Pin R_c 40-45
Test Load: Load Increased in 1,112 N (250 lb.) Increments at 1.0 Min. Up to 4,448 N (1,000 lb.) Load Maintained Until Failure*

Solid Film	Average** Torque - N m. (in-lb)	Average** Wear-Life (min.)
DAG 253	0.994 (8.8)	99
Drilube No. 1	0.599 (5.3)	335
Drilube 805	1.74 (15.4)	12
Electrofilm 2306	1.57 (13.9)	10
Electrofilm 5396	0.926 (8.2)	169
Lubribond "A"	0.542 (4.8)	66
Everlube 620	0.881 (7.8)	93
Everlube 811	0.825 (7.3)	67
Fel-Pro C-200	0.395 (3.5)	564
Fel-Pro C-300	0.610 (5.4)	424
MLR-2 (NPI 425) (VAC KOTE 18.07)	0.316 (2.8)	502
MLF-5	0.972 (8.6)	86
MLF-9	0.542 (4.8)	57
Molykote X-15	1.15 (10.2)	27
Molykote X-106	0.802 (7.1)	242
Molykote 321	0.452 (4.0)	115
NPI-14	0.904 (8.0)	71
Vitrolube	0.599 (5.3)	727
Polylube No. 500	0.723 (6.4)	247
RIA No. 9	0.599 (5.3)	305
Surfkote M-1284	0.566 (5.0)	246
Surfkote A-1625	0.757 (6.7)	23

Notes: * Failure is indicated by a torque rise of 0.566 N m. (5.0 in-lb). above the steady state value, or breakage of shear pin.
** Average of 6 test runs.

TABLE 3

PELLET WEAR-LIFE TESTS

Test Method:	Pellet Wear-Plate Equipment, Pellet, 440-C Stainless, R_c 15-20; Wear-Plate, 440-C Stainless, R_c 55-59
Test Condition:	Load, 93,079 N/m^2 (13.5 psi); Speed, 3.88 m/sec (765 fpm); Ambient Temperature; Nitrogen Atmosphere
Wear-Life:	High-Friction Shut-off Switch Set for Maximum Friction Coefficient - 0.30.

Solid Film	Mean Average Wear-Life (hr.)	Log Mean Average Wear-Life (hr.)
DAG 253	4.1	3.80
Drilube No. 1	5.5	3.24
Drilube 805	4.2	1.92
Electrofilm 2306	26.1	20.64
Electrofilm 5396	2.7	1.8
Lubribond "A"	3.4	2.82
Everlube 620	4.7	4.32
Everlube 811	9.5	8.54
Fel-Pro C-200	1.7	1.26
Fel-Pro C-300	3.1	2.39
MLR-2 (NPI 425) (VAC KOTE 18.07)	83.8	66.4
MLF-5	31.2	28.3
MLF-9	34.2	32.34
Molykote X-15	11.3	7.40
Molykote X-106	5.1	3.65
Molykote 321	6.9	4.70
NPI-14	7.1	3.64
Vitrolube	8.0	3.8
Polylube No. 500	6.7	4.64
RIA No. 9	1.8	1.77
Surfkote M-1284	6.3	4.68
Surfkote A-1625	2.5	2.91

Notes: *Average of 20 test runs.

TABLE 4

ELECTRICAL CONDUCTIVITY AND VACUUM WEIGHT LOSS

Solid Film	Electrical Resistance Ohms 0.0254 Meter Gap (1.0 in.)	Vacuum Weight Loss** $Kg/m^2 \times 10^{-1}$ (mg/cm^2)
DAG 253	5,000	0.0775
Drilube No. 1	500,000	0.186
Drilube 805	200,000	0.062
Electrofilm 2306	10,000	0.171
Electrofilm 5396	25,000	0.000
Lubribond "A"	3,000,000	0.155
Everlube 620	44,000	0.1395
Everlube 811	7,000	0.062
Fel-Pro C-200	12,200	0.031
Fel-Pro C-300	1,835	0.0155
MLR-2 (NPI 425) (VAC KOTE 18.07)	10,000,000	0.0775
MLF-5	2,500	0.0465
MLF-9	6,000	0.340
Molykote X-15	875	0.1085
Molykote X-106	640	0.124
Molykote 321	560	0.186
NPI-14	16,300	0.233
Vitrolube	*	*
Polylube No. 500	745	0.0775
RIA No. 9	10,000,000	0.155
Surfkote M-1284	400,000	0.233
Surfkote A-1625	85,000	0.0775

Notes: * No samples obtained.

** Vacuum environment, 1.3332×10^{-4} N/m^2 (10^{-6} torr) at room temperature for 528 hr.

TABLE 5

VACUUM FRICTION AND WEAR-LIFE

Test Method: Pellet-Wear Plate Equipment; Pellet, 440-C Stainless R_c 15-20; Wear-Plate, 440-C Stainless R_c 55-59

Test Condition: Load, 15,170 N/m^2 (2.2 psi); Speed, 3.88 m/sec (765 fpm)

Environment: (1) Vacuum, 1.33332 x 10^{-3} N/m^2 (10^{-5}) torr, Nitrogen
(2) Ambient, Air
(3) 204°C (+400°F), Nitrogen

Solid Film		Friction Coefficient Static (average)*	Friction Coefficient Dynamic (average)*	Wear-Life Minutes (average)*
DAG 253	-73°C (-100°F) (1)	0.30	0.20	145
	Ambient (2)	0.14	0.14	69
	204°C (+400°F) (3)	0.30	0.18	136
Drilube No. 1	-73°C (-100°F) (1)	0.18	0.15	435
	Ambient (2)	0.25	0.23	48
	204°C (+400°F) (3)	0.30	0.20	2,065
Drilube 805	-73°C (-100°F) (1)	0.32	0.28	60
	Ambient (2)	0.20	0.19	78
	204°C (+400°F) (3)	0.20	0.07	618
Electrofilm 2306	-73°C (-100°F) (1)	0.35	0.20	45
	Ambient (2)	0.39	0.14	83
	204°C (+400°F) (3)	0.12	0.07	65
Electrofilm 5396	-73°C (-100°F) (1)	0.29	0.18	54
	Ambient (2)	0.33	0.23	58
	204°C (+400°F) (3)	0.14	0.17	70
Lubribond "A"	-73°C (-100°F) (1)	0.32	0.15	33
	Ambient (2)	0.33	0.18	60
	204°C (+400°F) (3)	0.33	0.10	113
Everlube 620	-73°C (-100°F) (1)	0.30	0.19	16
	Ambient (2)	0.30	0.20	123
	204°C (+400°F) (3)	0.13	0.15	130
Everlube 811	-73°C (-100°F) (1)	0.18	0.28	1
	Ambient (2)	0.27	0.15	60
	204°C (+400°F) (3)	0.25	0.12	58

TABLE 5 (Continued)

Solid Film			Friction Coefficient Static (average)*	Friction Coefficient Dynamic (average)*	Wear-Life Minutes (average)*
Fel-Pro C-200	-73°C (-100°F)	(1)	0.25	0.23	95
	Ambient	(2)	0.29	0.19	69
	204°C (+400°F)		0.24	0.15	72
Fel-Pro C-300	-73°C (-100°F)	(1)	0.24	0.18	217
	Ambient	(2)	0.59	0.20	80
	204°C (+400°F)	(3)	0.27	0.22	25
MLR-2 (NPI 425) (VAC KOTE 18.07)	-73°C (-100°F)	(1)	0.35	0.30	90
	Ambient	(2)	0.23	0.18	75
	204°C (+400°F)	(3)	0.23	0.05	5,178
MLF-5	-73°C (-100°F)	(1)	0.25	0.28	137
	Ambient	(2)	0.29	0.15	69
	204°C (+400°F)	(3)	0.14	0.10	480
MLF-9	-73°C (-100°F)	(1)	0.23	0.18	744
	Ambient	(2)	0.30	0.20	768
	204°C (+400°F)		0.21	0.15	1,056
Molykote X-15	-73°C (-100°F)	(1)	0.30	0.21	109
	Ambient	(2)	0.30	0.12	91
	204°C (+400°F)	(3)	0.17	0.09	729
Molykote X-106	-73°C (-100°F)	(1)	0.25	0.23	50
	Ambient	(2)	0.29	0.18	59
	204°C (+400°F)	(3)	0.23	0.16	57
Molykote 321	-73°C (-100°F)	(1)	0.24	0.20	3
	Ambient	(2)	0.33	0.18	80
	204°C (+400°F)	(3)	0.22	0.13	60
NPI-14	-73°C (-100°F)	(1)	0.28	0.20	44
	Ambient	(2)	0.27	0.23	92
	204°C (+400°F)	(3)	0.23	0.09	75
Vitrolube	-73°C (-100°F)	(1)	0.30	0.28	38
	Ambient	(2)	0.20	0.20	60
	204°C (+400°F)	(3)	0.09	0.15	42

TABLE 5 (Concluded)

Solid Film			Friction Coefficient Static (average)*	Friction Coefficient Dynamic (average)*	Wear-Life Minutes (average)*
Polylube No. 500	-73°C (-100°F)	(1)	0.33	0.18	36
	Ambient	(2)	0.30	0.22	64
	204°C (+400°F)	(3)	0.20	0.05	51
RIA No. 9	-73°C (-100°F)	(1)	0.35	Would not start	No time
	Ambient	(2)	0.35	0.13	78
	204°C (+400°F)	(3)	0.15	0.08	48
Surfkote M-1284	-73°C (-100°F)	(1)	0.25	0.25	90
	Ambient	(2)	0.20	0.14	60
	204°C (+400°F)	(3)	0.15	0.18	120
Surfkote A-1625	-73°C (-100°F)	(1)	0.29	0.23	26
	Ambient	(2)	0.35	0.18	75
	204°C (+400°F)	(3)	0.30	0.10	65

Notes: * Average of 3 tests.

TABLE 6

JOURNAL BEARING WEAR-LIFE TESTS*

(Average of Three Tests at Each Load)

Solid Film	Film Thickness (in.) a/		Bearing Wear-Life: Condition A, Load = 2×10^7 N/m^2 (3,000 psi), Speed = 8.4×10^{-2} m/sec (16.5 fpm)		Bearing Wear-Life: Condition B, Load = 6.8×10^7 N/m^2 (10,000 psi), Speed = 1.7×10^{-2} m/sec (3.3 fpm)	
	Pin	Bushing	Minutes	Cycles	Minutes	Cycles
DAG 253	0.0008	0.0007	1,813	181,300	5,580	111,600
Drilube No. 1	0.0005	0.0003	1,669	166,900	3,030	60,600
Drilube 805	0.0011	0.0007	856	85,600	3,453	69,060
Electrofilm 2306	0.0006	0.0005	399	39,900	1,600	32,000
Electrofilm 5396	0.0003	0.0004	1,476	147,600	1,873	37,460
Lubribond "A"	0.0004	0.0004	1,770	177,000	3,235	64,700
Everlube 620	0.0003	0.0002	965	96,500	3,405	68,100
Everlube 811	0.0003	0.0005	2,054	205,400	4,665	93,293
Fel-Pro C-200	0.0006	0.0002	236	23,600	1,236	24,720
Fel-Pro C-300	0.0008	0.0002	900	90,000	4,620	92,400
MLR-2 (NPI 425) (VAC KOTE 18.07)	0.0002	0.0003	487	48,700	1,435	28,700
MLF-5	0.0004	0.0001	1,148	114,800	3,166	63,333
MLF-9	0.0005	0.0004	586	52,000	1,835	36,700
Molykote X-15	0.0014	0.0006	887	88,700	3,435	68,700
Molykote X-106	0.0010	0.0004	4,842	484,200	8,680	173,600
Molykote 321	0.0006	0.0006	1,215	121,500	4,672	94,446
NPI-14	0.0005	0.0004	1,774	177,400	4,762	95,240
Vitrolube	0.0008	**	773	77,300	2,037	40,740
Polylube No. 500	0.0012	0.0004	960	96,000	2,174	43,480
RIA No. 9	0.0010	0.0005	525	52,500	4,507	90,140
Surfkote M-1284	0.0013	0.0008	2,916	291,600	7,275	145,500
Surfkote A-1625	0.0002	0.0004	425	42,500	3,990	79,800

Notes: * All tests conducted in ambient environment conditions.
** Thickness not determined.

a/ Film thickness can be converted to SI units by multiplying thickness times 2.54×10^{-2} = meters.

TABLE 7

DRY LUBRICANT WEAR-LIFE--INSTRUMENT-TYPE SPUR GEARS

Conditions:
Load: 1.4×10^{-1} N m. (20 in-oz)
Speed: 1800 rpm
Temperature: ambient (no heat added)
Atmosphere: dry nitrogen

Gears:
48 pitch, 55 and 56 teeth
20 degrees pressure angle, 3.17×10^{-3} m. (1/8 in.) face
303 stainless steel
AGMA class 12

Lubricant	Binder	Lubricant-to-Binder Ratio	Log Mean Average Life (hr.)
20 w mineral oil	--	--	679.4
MLF-5	sodium silicate		36.1
MLF-9	Al. phosphate		42.7
MLR-1	PI-1101		112.7
MLR-1-A*	PI-1101	1.0/0.27	118.0
MLR-1-1*	PI-1101	1.0/0.18	64.0
MLR-1-2*	PI-1101	1.0/0.36	71.0
MLR-1-L*	PI-1101	1.0/0.27	70.0
MLR-1-A[a/]	PI-1101	1.0/0.27	4.4
MLR-1-A[b/]	PI-1101	1.0/0.27	67.3
MLR-2 (NPI 425) (VAC KOTE 18.07)	PI-4701		36.1
MLR-2-5	PI-4701		39.4
MLR-2[a/]	PI-4701		23.0
MLR-15-7*	skybond 704	1.0/0.41	72.0
MLR-15-8*	skybond 704	1.0/0.26	109.0
MLR-15-9*	skybond 704	1.0/0.63	72.0
MLR-20			17.6
MLR-21			31.4
MLR-30			17.95
FEL-PRO	C-200 (commercial, proprietary)		22.8
FEL-PRO	C-200/MLR-1-A		15.0
VAC-KOTE			1.6
Gold plating (over electrolytic nickel)			0.2
Sputtered MoS_2			6.1

* MoS_2 particle size for standard MLR- and MLF- films is 4.5×10^{-5} m. (44 µ) or less (microsize). Particle size for all tests marked with * is 4.5 to 7.7×10^{-5} m. (44 to 77 µ), Type Z.

a/ These tests used 1.6×10^{-3} m. (1/16 in.) face gears.

b/ These tests used 1.6×10^{-3} m. (1/16 in.) face gears and were run at 4.9×10^{-2} N m. (7 in-oz) loading. The stress level is equivalent to a 3.17×10^{-3} m. (1/8 in.) face gear of 1.4×10^{-1} N m. (20 in-oz) loading.

TABLE 8

DRY LUBRICANT WEAR-LIFE--LOW SPEED GEAR TESTS

Load: 5.29 N m. (3.9 ft-lb)

Speed: 150 rpm

Temperature: Ambient (no heat added)

Atmosphere: Dry nitrogen

Gear Data: 16 pitch, 64 tooth, 20 degree pressure angle, steel, 6.35×10^{-3} m. (1/4 in.) face, and 1.27×10^{-2} m. (1/2 in.) face

Lubricant	Wear-Life (hr)	Log Mean Average Life (hr)
MLR-1-A[a/]	24.74	
MLR-1-A[a/]	29.50	27.6
MLR-1-A	66.42	
MLR-1-A	34.62	48.0
MLR-20	37.68	
MLR-20	24.17	30.2
MLR-21	26.08	
MLR-21	40.07	32.33
MLR-30	34.45	
MLR-30	63.48	46.76

a/These gears were cast iron with 14-1/2 degree pressure angle. They were available from stock and used for check-out purposes only while 20 degree pressure angle gears were on order.

TABLE 9

WEAR-LIFE OF SOLID LUBRICANT COATED WORM GEARS

Temperature: Room ambient
Speed: 1,750 rpm (worm)
Worm: Case hardened alloy steel
25 degrees pressure angle
17 degrees, 28 sec. lead angle
4 threads
1.63×10^{-2} m. (0.643 in.) pitch diameter

Atmosphere: Air
Worm Gear: Nickel bronze alloy
25 degrees pressure angle
17 degrees, 28 sec. lead angle
40 tooth
5.16×10^{-2} (2.032 in.) pitch diameter
Input: 0.280 horsepower

Test	Lubricant	Average Efficiency (%)	Wear-Life (Revolutions)	Average Wear-Life (Revolutions)
-	20 W Oil	63-66	-	
-	140 W Oil	59-62	-	
-	600 W Oil	63-66	-	-
1-A a/	MLF-5	50-55	0.24×10^6	
1-B a/	MLF-5	56-66	0.35×10^6	0.30×10^6
2-A	MLF-9	69-72	1.36×10^6	
2-B	MLF-9	69-72	0.92×10^6	1.14×10^6
3-A b/	MLR-1	-	-	
3-B	MLR-1	29-72	1.81×10^6	
4-A-0 c/	MLR-1	60-65	1.34×10^6	
4-B-0	MLR-1	60-65	0.62×10^6	
5-A-0	MLR-1	69-71	1.98×10^6	
5-B-0 b/	MLR-1	-	-	1.44×10^6
6-A-0	MLR-2 (NPI 425) (VAC KOTE 18.07)	54-57	3.56×10^6	
6-B-0	MLR-2	51-54	1.67×10^6	
7-A-0	MLR-2	75-85	2.94×10^6	
7-B-0 b/	MLR-2	-	-	2.72×10^6

a/ A-front side of teeth; B-black side of teeth.
b/ Test stopped early, uneven tooth contact.
c/ 0 indicates oil run-in used.

TABLE 10

ATM ROLL RING SIMULATOR (RACK & PINION)*

Pinion Lubricant (A-286 steel)	Rack Lubricant (410 SS)	Torque N m. (ft-lb)	Total Operating Distance m. (ft.)
MLR-2 (NPI 425) (VAC KOTE 18.07)	None	1.9 (1.4)	7,462 (24,480)
Glass bonded MoS_2	None	1.9 (1.4)	18,824 (61,760)
Glass bonded MoS_2	None	5.29 (3.9)	18,824 (61,760)
MLR-1	None	1.9 (1.4)	19,586 (64,259)
MLR-1	None	5.29 (3.9)	357 (1,170)
MLR-1	None	5.29 (3.9)	686 (2,250)
MLR-1	None	5.29 (3.9)	4,402 (13,260)
MLR-1	Air drying bonded MoS_2 lube	1.9 (1.4)	18,824 (61,760)
MLR-1	Air drying bonded MoS_2 lube	5.29 (3.9)	20,820 (68,340)
MLR-1	Air drying bonded MoS_2 lube	9.49 (7.0)	1,899 (6,230)

* Tests made at 10^{-7} torr.

TABLE 11

ATM CMG ACTUATOR GEAR TRAIN EVALUATION*

Gear Material	Gear Hardness	Lubricant	Total Operating Time	Total Pinion Revolutions
420 Series steel	RC 32-38	MLR-2**	Intermittent 29 days	600,000
420 Series steel	RC 32-38	MLR-2**	7 Days	148,000
420 Series steel	RC 32-38	MLR-2**	28 Days	590,000
420 Series steel	RC 32-38	MLR-2**	56 Days and 5 hr	1,180,000
Nitralloy	Case RC 58	MLR-1	12 Days and 10 hr	260,000
Nitralloy	Case RC 58	MLR-1	6 Days and 5 hr	130,000

* Tests made at 10^{-7} torr.

** Available as NPI 425 and VAC KOTE 18.07.

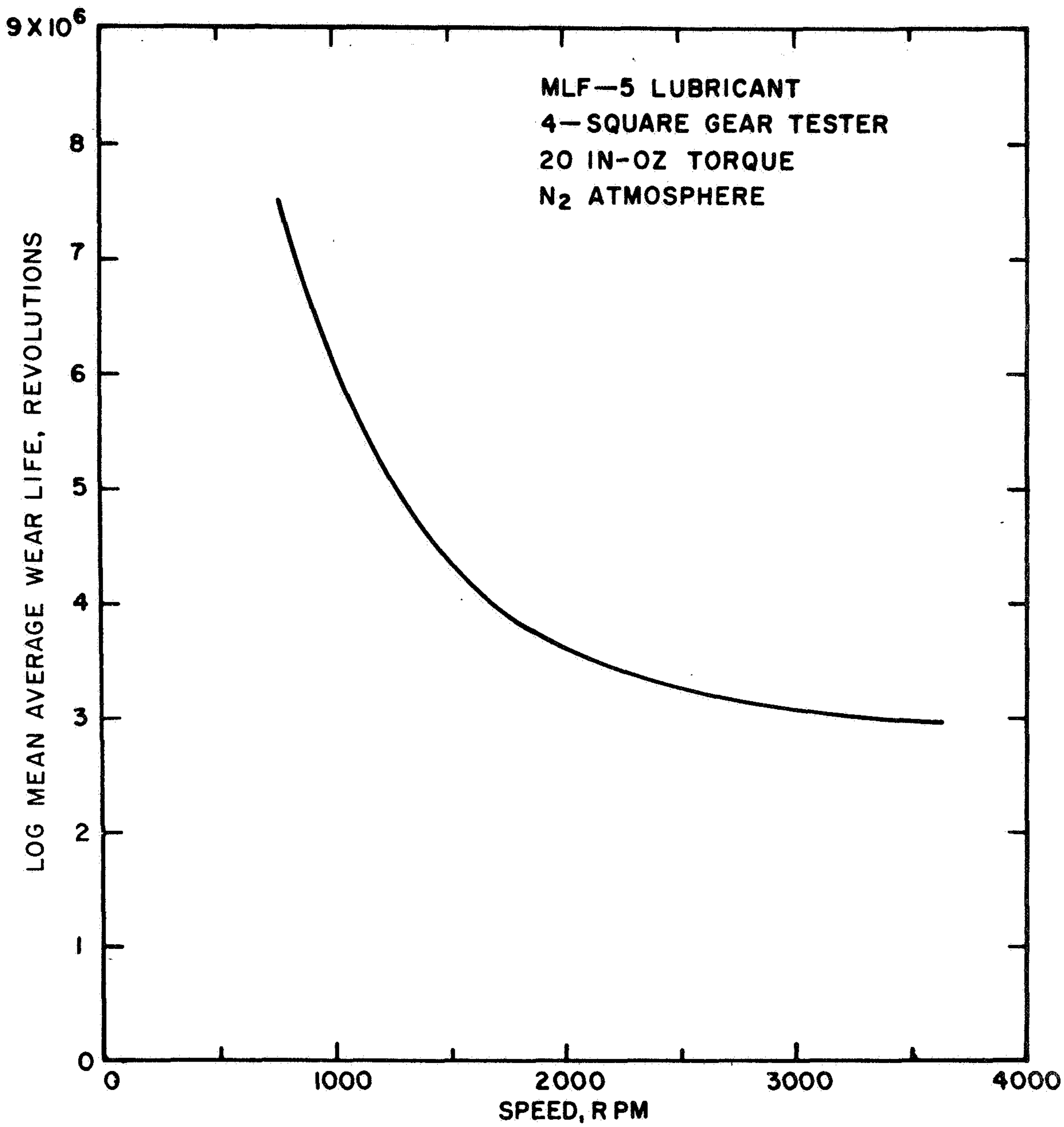

Figure 1 - Lubricant Film Wear-Life Vs. Speed

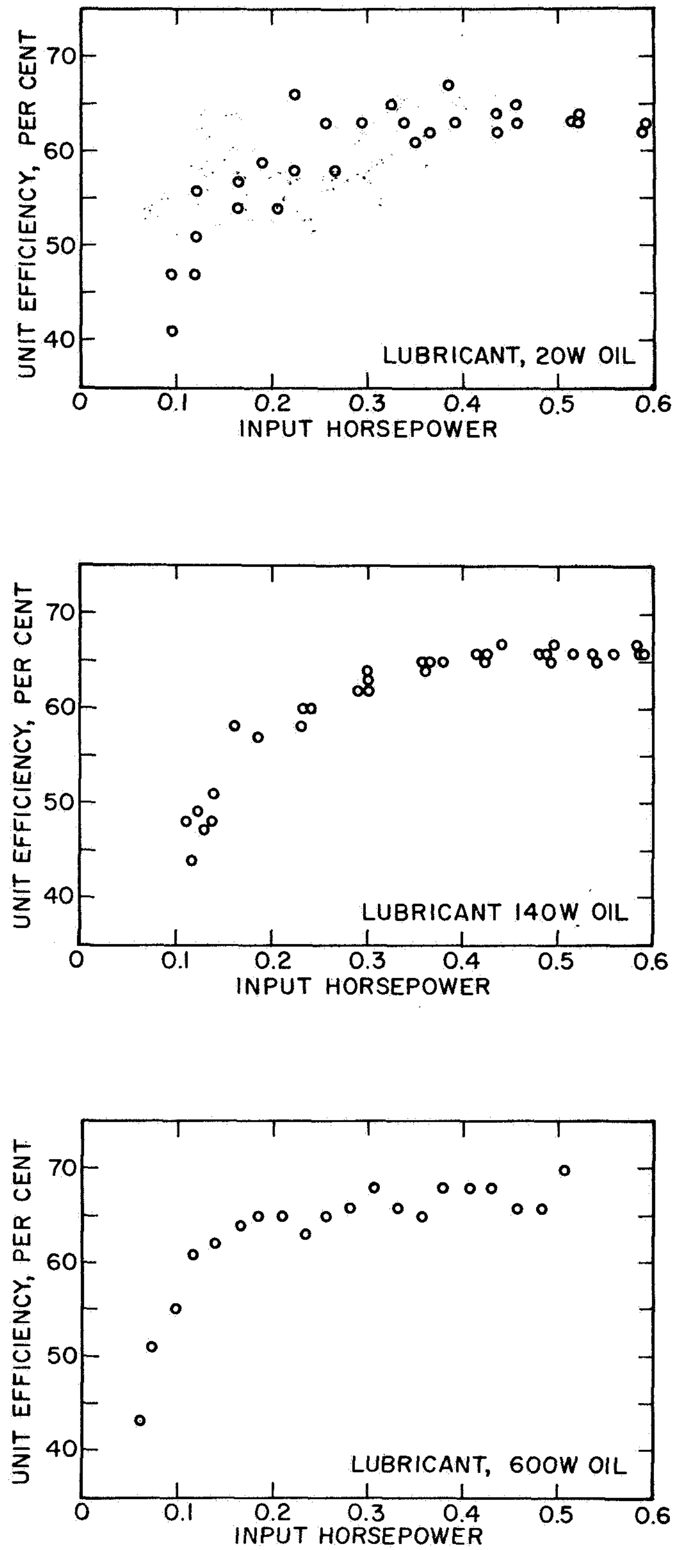

Figure 2 - Oil Lubrication Efficiency Vs. Input Horsepower

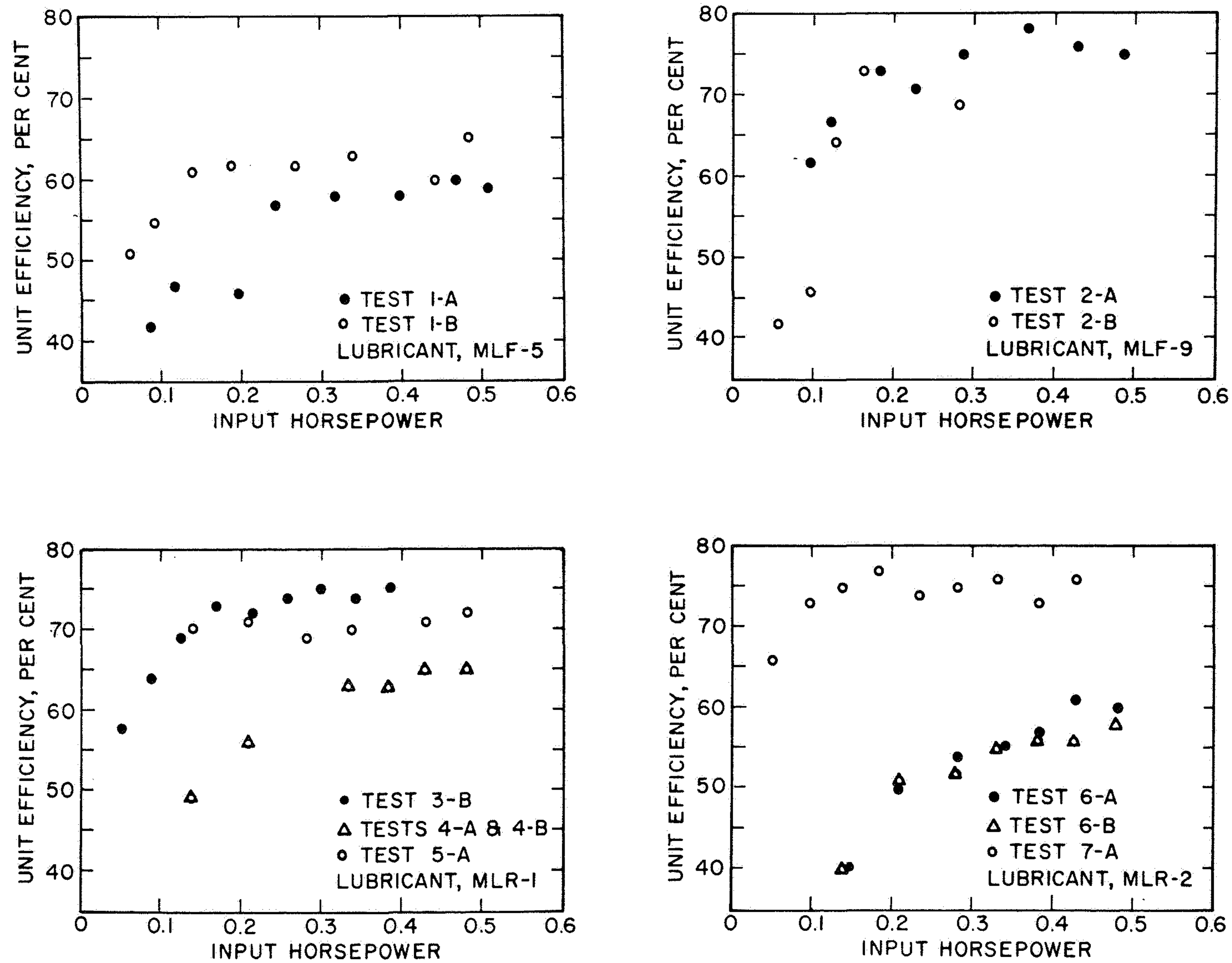

Figure 3 - Solid Film Lubrication Efficiency Vs. Input Horsepower

TABLE 12

SELF-LUBRICATING MATERIALS - POLYMIDES

Designation	Filler Material	Friction Values	TENSILE STRENGTH N/m^2 (PSI) at R. T.	Uses
SP-1 (Vespel)	None	0.04-0.09 in N_2 0.29 in Air	$8.96 \times 10^{+7}$ (13,000)	High Temp. Mechanical and Electrical Parts
SP-21 "	15% by Wt. Graphite	0.06-0.08 in N_2 0.12-0.24 in Air	$6.2 \times 10^{+7}$ (9,000)	Non-Lubricated Bearings and Seals
SP-22 "	40% by Wt. Graphite	0.09-0.30 in Air	$5.2 \times 10^{+7}$ (7,600)	Bearings and Seals with Low Thermal Expansion
SP-211 "	15% by Wt. Graphite 15% by Wt. P.T.F.E.	0.09-0.11 in Air	$4.14 \times 10^{+7}$ (6,000)	Bearings and Seals with Requiring Low Initial Friction
SP-31 "	15% by Wt. MoS_2	0.17-0.25 in Air 0.03 in Vacuum	$8.14 \times 10^{+7}$ (11,800)	Seals and Bearings in Vacuum or Dry Areas
SP-5 "	30% by Vol. Short Glass Fiber	-	$3.72 \times 10^{+7}$ (5,400)	High Temp. Mechanical Parts Requiring Low Thermal Expansion
FEURLON-CT	Graphite-P.T.F.E.		$4.28 \times 10^{+7}$ (6,200) Min.	For Areas Where Temperatures are Less Than 149°C (300°F)
FEURLON-AW	Silver-WS_2		$3.86 \times 10^{+7}$ (5,600) Min.	Vacuum and Inert Environments
FEURLON-C	Graphite		$4.4 \times 10^{+7}$ (6,400) Min.	Air Operation Over the Temp. Range of 149-399°C (300°F-750°F)
MELDIN-PI	None	0.5	$7.99 \times 10^{+7}$ (11,600)	Seals, Thrust Washers, Bearing Retainers, Piston Rings
MELDIN-PI-30X	Lubricitive Additive	0.2-0.25	$2.29 \times 10^{+7}$ (3,320)	Same as Above
MELDIN-PI-15Y	Lubricitive Additive	0.3-0.35	$4.96 \times 10^{+7}$ (7,200)	Same as Above

Note: All information obtained from manufacturer's literature.

(Vespel) SP- Trade name of E. I. DuPont De Nemours & Company

FEURLON- " " " Bemol Corporation

MELDIN - " " " Dixon Corporation

TABLE 13

SELF-LUBRICATING MATERIALS - FLUOROCARBONS

Designation	Filler Material	Friction Values	TENSILE STRENGTH N/m^2 (PSI) at R. T.	Uses
TEFLON	None	0.13	$1.03 \times 10^{+7}$ (1500) Min.	Lightly Loaded Bearings
DUROID 5813	Micro-Fiber Glass MoS_2	0.018	$4.83 \times 10^{+7}$ (7000) Min.	Bearing Retainers, Journal Bearings
DUROID 4300	Bronze MoS_2	-	$9.8 \times 10^{+6}$ (1430)	Same as Above-Higher Load Capacity
RULON A[a/]	-	.12-.19	$9.65 \times 10^{+6}$ (1400)Min.	Bushings-Retainers Seals Etc.
SALOX-M2[b/]	Metal Powder		$1.21 \times 10^{+7}$ (1735) Min.	
BARTEMP	Same as DUROID 5813		-	Crowned Bearing Retainers

TEFLON - Trade Name of DuPont
DUROID - Trade Name of Rogers Corporation
RULON - " " " Dixon Corporation
SALOX - " " " Allegheny Plastics
BARTEMP- " " " The Barden Corporation

a/ Several other Rulon Materials are available.
b/ Several other Saylox materials are available.

TABLE 14

SELF-LUBRICATING MATERIALS - MISCELLANEOUS COMPOSITES

Designation	Filler Material	Friction Values	TENSILE STRENGTH N/m^2 (PSI) at R.T.	Uses
DELRIN 100 (Acetal Resin)	None	0.1-0.3	-	Bearings - Lightly Loaded Gears
DELRIN-AF (Acetal Resin)	Fluorocarbon Fibers	0.05-0.15	-	Bearing and Sliding Applications
ZYTEL (Nylon)	None	0.04-0.14	-	Lightly Load Bearing and Sliding Applications
POLYPHENYLENE SULFIDE (PPS) (Ryton)	Asbestos Teflon and Others	0.2-0.4	$4.45 \times 10^{+7}$ (10,800)	Seals, Bearing, Sliding Surfaces in Reactive Environments, High Temperatures
MOLALLOY			Compressive Strength N/m^2 (PSI) at R. T.	
Pm 101	MoS_2 and Metal Powders	0.03	$7.6 \times 10^{+7}$ (11,000)	Ball Bearing Separators
Pm 103	" " " "	-	$7.5 \times 10^{+8}$ (109,000)	High Load Bearings
Pm 104	" " " "	-	$6.07 \times 10^{+8}$ (88,000)	" " "
Pm 105	" " " "	-	$1.9 \times 10^{+8}$ (28,000)	Electrical Brushes
Pm 108	" " " "	0.5	$4.48 \times 10^{+8}$ (65,000)	Clutch Facing

DELRIN - Trade Name of DuPont
ZYTEL - " " " "
RYTON - " " " Phillips Petroleum Company
MOLALLOY- " " " Pure Carbon Company

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AVI - APPENDICES A, B, & C

APPENDIX A

GLOSSARY FOR SOLID FILM LUBRICANTS

Binder: Material used to hold the pigment of a solid lubricant system to the substrate.

Carrier: Liquid, solvent or gas in which the lubricant solid is suspended to facilitate handling or application, but does not form part of the solid film lube or affect the adhesion properties.

Hard vacuum: Term used to denote a high vacuum $< 1.3332 \times 10^{-4}$ N/m^2 (low pressure, $< 10^{-6}$ torr).

Impact sensitivity: Tendency of some materials to react with liquid oxygen when subject to mechanical impact or vibration. This reaction is frequently explosive in nature.

"LOX": Abbreviation used to denote liquid oxygen.

"LOX" Compatible: Denotes solid film lubricants that have passed the "ABMA" test (97.6 joule) (72 ft-lb) impact in liquid oxygen with no reaction in accordance with MSFC-SPEC-106.

"LOX" resistant or "LOX" insensitive: Denotes solid film lubricants which do not react with and have some resistance to liquid oxygen, but have not passed or will not pass the ABMA "LOX" Impact Test.

Pigment: Solid lubricant material (MoS_2, graphite, etc.) used in a solid lubricant system.

Pretreatment: Usually refers to the treatment of a substrate or the base material to improve solid film adhesion or the corrosion protection.

Solid lubricant: A solid material that provides lubrication between two relatively moving surfaces.

Matrix lubricant: Two or more solid lubricants mixed together to form a solid lubricant compound.

TFE: Tetrafluoroethylene.

Torr: Unit of pressure adopted by the American Vacuum Society. It is defined in terms of standard atmosphere (1,013,250 dynes/cm^2). Torr is 1/760 atmosphere, or 1,340 dynes/cm^2. One torr is approximately 1.0 mm. mercury, and in SI units 133.322 N/m^2.

Solvent: Liquid used to thin solid lubricant solutions or to remove solid film lubricant from substrate.

APPENDIX B

SOLID FILM LUBRICANT SPECIFICATIONS

MIL-M-7866B; Molybdenum Disulfide, Technical, Lubrication Grade

This specification covers the requirements for procurement of one grade of powdered molybdenum disulfide, to be used for the lubrication of surfaces when boundary conditions exist. The powder shall have a purity (98.5% pure MoS_2, minimum) and a particle size (average, > 5 µm. and < 10 µm.) suitable for general lubricating use.

Uses: Intended for use as a dry lubricant or as a component with suitable specification oils or greases for special applications where other lubricants are not satisfactory. Reduces friction and wear under low and high sliding velocities; used as thread anti-seize for lightly loaded applications where fluid lubricant is objectionable; and is an effective lubricant over a wide range of temperatures.

Limitations: The unbonded lubricant does not give corrosion protection. The material must be bonded and cured to develop maximum lubrication potential; in this form it must also provide a minimum of 500 hr. corrosion protection in heat and high humidity conditions. Mixtures of this powder with oils or greases should not be done in field applications where performance data have not been established.

MIL-G-6711; Graphite, Lubrication

This material is a 200 mesh (80 µm.) high grade, powdered graphite for use preferably as a dry lubricant, but may be mixed with a proven specification oil.

Uses: Intended use is principally as a "dust-on" or "brush-on" dry powder lubricant for sliding surfaces (i.e., tracks, slides, grooves). It may be used over a wide temperature range.

Limitations: This material is a large particle size powder and is not recommended for blending with oils or greases, particularly in aircraft or aerospace applications. MIL-M-7866B molybdenum disulfide should be used in preference to this material, if possible.

MIL-L-8937A (ASG); Lubricant, Solid Film, Heat-Cured

This specification establishes the requirements for a solid film lubricant intended to reduce wear and prevent galling and seizure of metals.

Condensed specification requirements:

Material: Finely powdered lubricating solids dispersed in suitable binders are capable of being cured within 60 min. at 149°C (300°F).

Film appearance and thickness: The bonded film lubricant shall appear smooth and free from cracks, scratches, pinholes, blisters, bubbles, runs, sags, foreign matter, grit, rough particles, separation of ingredients, or other imperfections.

Film adhesion: The bonded solid film lubricant shall not be lifted from the test panel by the pressure-sensitive masking tape method. A uniform deposit of powdery material may cling to the tape, but lifting of any flakes or particles which expose any bare metal shall indicate unsatisfactory adhesion.

Thermal stability: The bonded solid film lubricant shall not flake, crack nor soften, and shall have satisfactory adhesion when tested for 3 hr. at -54°C (-65°F) and 260°C (+500°F).

Fluid resistance: The bonded solid film lubricant shall not soften, lift, blister, crack or peel, and shall have satisfactory adhesion when half immersed for 24 hr. at room temperature in each of the following fluids: standard hydrocarbon test fluid, aviation gasoline, jet fuel, hydraulic fluids (petroleum and nonpetroleum base), aircraft lubricating oils (petroleum and synthetic base), silicone fluid, and trichloroethylene.

Endurance life: The bonded solid film lubricant when tested in the Falex Lubricant Tester shall have an average life of not less than 120 min. at 4,448 N (1,000 lb.) gage load. The minimum life of any single run shall not be less than 100 min.

Load carrying capacity: The bonded solid film lubricant when tested in the Falex Lubricant Tester shall have a minimum load carrying capacity of 11,120 N (2,500 lb.) gage load.

Corrosion resistance: The bonded solid film lubricant on anodized aluminum panels shall show or cause no discoloration, pitting, formation of white deposits or other evidence of corrosion after 500 hr. at 49°C (120°F) and 95% humidity.

Uses: This solid film lubricant is intended for use on steel, titanium, aluminum, aluminum alloys and other metals. Useful where other lubricants are difficult to apply or where they may be contaminated by dirt and dust. Suitable for sliding motion surfaces, such as plain spherical bearings, flap tracks, hinges and cams.

Limitations: This solid film lubricant should not be used with oil or grease unless experience indicates otherwise. Because of the 149°C (300°F) cure temperature, it should not be used on materials which are adversely affected by exposure to this temperature. It should not be used where there is potential contact with liquid oxygen. Storage or shelf-life is limited and should not be used beyond 6 months from date of manufacture.

MIL-L-23398B; Lubricant, Solid Film, Air Drying

This specification establishes the requirements for an air-drying solid film lubricant intended to reduce wear and prevent seizing and galling (NATO Code S-749).

Condensed specification requirements:

Material: Finely powdered lubricating solids in suitable binder, which are in a spraying consistency. The applied film shall cure at room temperature, 25°C (77°F) in not more than 6.0 hr. Additives if necessary to meet specification requirements.

Film condition: The bonded solid film lubricant shall appear uniform in color, smooth, free from cracks, scratches, blisters, foreign matter, grit, rough particles, bubbles, pinholes, runs, sags, or other surface imperfections, and shall show no evidence of separation of ingredient.

Film adhesion: The bonded solid film lubricant shall not be lifted from the test panel by the pressure-sensitive masking tape method. A uniform deposit of powdery material may cling to the tape, but lifting of any flakes or particles which expose any bare metal shall indicate unsatisfactory adhesion.

Thermal stability: The bonded solid film lubricant shall not flake, crack or soften, and shall have satisfactory adhesion when tested for 3 hr. at -54°C (-65°F) and 260°C (+500°F).

Fluid resistance: The bonded solid film shall not flake, crack or peel, and shall have satisfactory adhesion after immersion for 24 hr. at room temperature in each of the following fluids: standard hydrocarbon test fluid, aviation gasoline, jet fuel, hydraulic fluid (petroleum base), lubricating oils (petroleum and synthetic base) and anti-icing/deicing/defrosting fluid, hydraulic fluids (nonpetroleum base), silicone fluid (Dow-Corning - 550 or equivalent), trichloroethylene, and lubricating oil internal combustion (heavy duty).

Endurance life: The bonded solid film lubricant when tested in the Falex Lubricant Tester shall have an average life of not less than 60 min. at 4,448 N (1,000 lb.) gage, and any single run shall not be less than 50 min. using manganese phosphatized specimens. Using zinc phosphate specimens the average life shall not be less than 120 min. and none less than 90 min.

Load capacity: The bonded solid film lubricant, tested in the Falex Lubricant Tester, shall have a minimum load capacity of 11,120 N (2,500 lb.) gage.

Corrosion protection: The bonded solid film lubricant on anodized aluminum panels and steel panels shall show or cause no discoloration, pitting, formation of white deposits, or other evidence of corrosion when subjected to high humidity conditions.

Storage stability: This solid film solution shall remain in a homogeneous blend showing no evidence of gelation after storage in a closed container for 12 months at room temperature, 25°C (77°F). After storage, the bonded solid film lubricant must conform to the other requirements of this specification.

Uses: This air-drying solid film lubricant is intended for use on steel, titanium, aluminum and aluminum alloys. It is useful where conventional fluid lubricants are difficult to apply or may be contaminated with dirt and dust. Generally suitable for sliding motion surfaces, such as plain spherical bearings, tracks, hinges, cams, etc. Recommended for applications where solid film lubricants that require elevated temperature cures cannot be applied because of material or other reasons, but may be heat cured at temperatures up to 121°C (250°F).

Limitations: This solid film lubricant should not be used with oil and grease unless experience indicates otherwise. Application should be conducted in a well ventilated area where no flame or ignition sources are present. This material is not a substitute for MIL-L-8937 lubricants, as it has lower wear-life and load carrying ability. Not for use on roller bearings. Should not be stored at temperatures above 49°C (120°F).

MIL-L-22273 (WEP); Lubricant, Solid Film, Heat Cured

Superseded by MIL-L-8937 (ASG).

MIL-L-25504 (USAF); Lubricant, Solid Film, Heat Cured

Superseded by MIL-L-8937 (ASG).

MIL-L-46010A (MR); Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting

This specification covers a resin-bonded, heat-cured, solid film lubricant intended to reduce wear, prevent galling and seizure, and provide corrosion protection to metals. This lubricant does not contain graphite or powdered metals.

Condensed specification requirements:

Materials: The lubricant shall consist of a dispersion of lubricative pigment or pigments in a thermosetting resin with or without additives.

Film thickness: The lubricant shall be capable of being applied by brush, dip or spray methods and cured to a film thickness of 0.508×10^{-5} and 1.27×10^{-5} m. (0.0002 and 0.0005 in.). All film measurements must be within these limits.

Wear-life: The cured lubricant film shall provide an average minimum Falex wear-life of 450 min. at 4,448 N (1,000 lb.) gage load. No single test shall have less than a 390-min. wear-life. A minimum of four tests is required.

Load carrying capacity: The cured lubricant film shall provide an average minimum Falex load carrying capacity of 8,896 N (2,000 lb.) gage. No single test shall have a load capacity of less than 7,784 N (1,750 lb.) gage. A minimum of two tests is required.

Corrosion protection: The cured lubricant film when applied to 0.0762 x 0.1524 m. (3 x 6 in.) steel sheet (SAE 1009) test panels shall show a maximum of three rust dots per panel after a salt spray exposure of 100 hr.

Film adhesion: The cured lubricant film shall not be lifted from the test panel by the pressure-sensitive masking tape method. A uniform deposit of powdery material may cling to the tape, but lifting of any flake or particles which expose any bare metal shall indicate unsatisfactory adhesion.

Fluid resistance: The cured lubricant film shall pass the film adhesion test after half immersion for 24 hr. at 23°C (74°F) in each of the following fluids: standard hydrocarbon test fluid, aviation gasoline, jet fuel, hydraulic fluids (petroleum and nonpetroleum base), aircraft lubricating oils (petroleum and synthetic base), silicone fluid, and trichloroethylene.

High and low temperature stability: The cured lubricant film shall pass the film adhesion test after high temperature of 260°C (500°F) for 3 hr., and low temperature cycle of 24 hr. placed on a cake of dry ice (carbon dioxide).

Storage stability: The lubricant dispersion stored in a closed container for 6 months at room temperature shall meet the wear-life and corrosion protection requirements of this specification.

Uses: This resin-bonded solid film is intended for use on aluminum, copper, copper alloys, steel, stainless steel, titanium, and chromium and nickel-bearing surfaces. Generally is suitable for sliding motion applications, such as plain and spherical bearings, tracks, hinges, threads, and cam surfaces. Useful under the following conditions: where conventional lubricants are difficult to apply or retain; where other lubricants may be contaminated by dirt or dust; temperature ranges between -54°C (-65°F) to 177°C (+350°F) in mechanisms operated at infrequent intervals; and in mechanisms to be lubricated for life.

Limitations: This film lubricant should not be used on materials adversely affected by the heat-cure cycles of 204°C (400°F) for 1.0 hr., or 149°C (300°F) for 2 hr. Application should be conducted in well ventilated areas where no flame or ignition source is present. The corrosion protection of this film is probably obtained by the phosphate coating applied to the base material. This lubricant shall contain no graphite or powdered metals.

MIL-L-46009 (MR); Lubricant, Solid Film, Air Drying (In Pressurized Containers)

This specification establishes the requirements for one grade of air-drying solid film lubricant packaged in self-pressurized containers; both the film lubricant properties and the aerosol container requirements are defined.

Condensed specification requirements:

Materials: The self-pressurized container and lubricant shall be of the following composition: a suitable fast air-drying binder carrier, a suitable powder lubricating pigment or mixture of lubricating solids; an additive may be used to improve properties of the lubricating film, and a pressure producing agent.

Film condition: The spray pattern shall be uniform in color, smooth and free from bubbles and runs. There shall be no evidence of separation of material ingredients.

Thermal stability: The solid film lubricant coated on steel panels shall show no deterioration after 5 hr. of exposure to temperatures of 204°C (400°F) or when placed on a cake of solid carbon dioxide (dry-ice).

Fluid resistance: Lubricant-coated metal plates and Falex specimens shall be placed in MIL-L-2104, Grade 10 engine oil for 24 hr. at 38°C (100°F). Metal plates must pass visual corrosion protection test and Falex specimens must provide a 120-min. wear-life at 4,448 N (1,000 lb.) gage load.

Wear-life: Falex pins and V-blocks shall be cleaned, phosphated and sprayed with dry film lubricant. Wear-life shall be a minimum of 120 min. at 4,448 N (1,000 lb.) gage load. Failure is indicated by a torque reading of 2.8 N m. (25 lb-in) or more.

Load capacity: Load carrying capacity of the dry film shall be determined using the Falex Lubrication Tester, cleaned and phosphated pins and V-blocks coated with the film lubricant. The minimum load capacity shall be 11,120 N (2,500 lb.) gage. Failure is indicated by a large increase in torque or by breakage of the shear or test pin.

Corrosion resistance: Spray dry film lubricant, 1.016 to 1.524×10^{-5} m.(0.0004 to 0.0006 in.) thick, on cold rolled steel (SAE 1009), and allow to air-dry. A 30-hr. exposure to high humidity in a desiccator two-thirds full of water at room temperature shall show no visual evidence of corrosion.

Spray duration and weight: The container shall provide a minimum effective spray period of 270 sec. (spray containing lubricative pigment). The container shall contain a minimum of 0.3331 kg. (11.75 oz.) of material, including a minimum of 0.01418 kg. (0.5 oz.) of solids.

Storage stability: The solid film lubricant in the container shall meet the requirements of this specification after 1 year under standard laboratory conditions.

Uses: The air-drying, aerosol spray lubricant is intended for use on metallic-bearing surfaces where moderate wear-life and corrosion protection are desired. It can be used to repair worn bearing surfaces originally coated with thermosetting resin-bonded solid film lubricants. This lubricant can also be used to prevent scoring and seizure on initial start-up of new or overhauled heavily loaded equipment. Although intended as an air-dry film lubricant, it may also be cured at temperatures up to 121°C (+250°F).

Limitations: The use of this solid film lubricant is not recommended on rolling element bearings. The wear-life is also drastically reduced by the presence of lubricating oils. The lubricant and container should not be stored at temperatures above 49°C (120°F) and should be kept away from direct sunlight, stoves, radiators and other heat sources.

MIL-L-81329A (ASG); Lubricant, Solid Film, Extreme Environment

This specification establishes the requirements for a solid film lubricant to be used in extreme environments, including temperatures from -184°C (-300°F) to 399°C (+750°F) liquid oxygen, and vacuum, to reduce wear and prevent galling and seizing of metal surfaces.

Condensed specification requirements:

Material: High quality lubricating solids in a suitable binder at spraying consistency. Organic materials are not suitable for this lubricant. The lubricant material shall be nonflammable when heated by a Bunsen Burner flame. The applied lubricant film shall be capable of being cured by the following heating schedule: 1/2 hr. at 25°C (77°F), 2 hr. at 82°C (180°F), and 2 hr. at 149°C (300°F).

Appearance and film thickness: The solid film lubricant shall be free of surface imperfections and show no evidence of separation of material ingredients; the finished film thickness shall be between 2.54 and 3.56 x 10^{-5} m. (0.0010 and 0.0014 in.).

Film adhesion: The bonded film lubricant shall not be lifted from the test panel by the pressure-sensitive masking tape method. A uniform deposit of powdery material may cling to the tape, but lifting of any flakes or particles which expose any bare metal shall indicate unsatisfactory adhesion.

Thermal stability: The bonded solid film lubricant applied to 18-8 stainless steel panels and exposed to 399°C (750°F) for 3 hr. followed by 1 hr. at -184°C (-300°F) shall show no flaking, cracking or softening.

Endurance life: The solid film lubricant shall have a minimum average life of 80 min. on the Falex Lubricant Tester at 4,448 N (1,000 lb.) gage load. A minimum of four tests is required. No single test shall have a life of less than 70 min.

High temperature performance: The solid film lubricant tested by the method and equipment described in Federal Standard No. 791, Method 333, shall demonstrate a useful life of 500 hr. at 399°C (750°F) and 10,000 rpm continuous running on M-10 steel, SAE 204 bearing with ABEC-3 tolerance.

Vacuum performance: The solid film lubricant shall be applied to an anti-friction bearing and subjected to a vacuum environment of (1.0×10^{-6}) 1.333×10^{-4} N/m^2 torr at 538°C (1000°F) and 1,250 rpm. A 22.24 N (5.0 lb.) axial and a 13.34 N (3.0 lb.) radial load shall be applied to the bearing. The solid film lubricant shall demonstrate a minimum life of 100 hr. Failure is indicated by 7°C (20°F) rise in temperature of the bearing case or a 50% increase in power required.

Shock sensitivity with "LOX": The solid film lubricant tested in accordance with U.S. Air Force Specification Bulletin 527 shall give no reaction in 20 test drops at 94.91 joule (70 ft/lb) energy level. The solid film lubricant shall be spray deposited and cured in test cups prior to testing.

Storage stability: A closed quart container of the solid film solution shall be stored at 25°C (77°F) for 6 months. It shall then be mechanically agitated for 5 min., the container opened, and the lubricant examined for homogeneity. Cured solid film specimens shall then pass the film adhesion, thermal stability and endurance life tests.

Uses: This solid film lubricant is intended for use in liquid oxygen systems, space vehicles, bearing and other equipment where the environments of temperature, nuclear radiation and vacuum will not permit the use of conventional lubricants or organic-bonded solid film lubricants.

Limitations: This solid film lubricant should not be used on materials which may be adversely affected by the required cure temperature of 149°C (300°F). It should not be used with oils or greases unless experience indicates otherwise.

MSFC-SPEC-253A; Lubricant, Dry Film, Ceramic, MLF-5 and MLF-9 (Preparation and Application)

This specification covers the requirements for the preparation of parts and application of two types of dry film lubricating materials, designated MLF-5 and MLF-9, that have low friction and will support high loads.

Condensed specification requirements: Surface finish and preparation for these solid film lubricants required a chemically and mechanically cleaned surface with a smooth dry-honed finish not exceeding 0.20 to 0.33 x 10^{-6} m. (8 to 13 µin.) (rms).

MLF-5 solid film: Preparation requires careful mixing of specified amounts and particle sizes of several solid film powders, including: molybdenum disulfide, graphite, gold and sodium silicate in specified proportions of distilled water. Powdered ingredients for this solid film lube shall pass through a 325-mesh sieve (44 µm.).

MLF-9 solid film: Preparation requires careful mixing of specified amounts and particle sizes of several granular powders, including: molybdenum disulfide, graphite, bismuth and aluminum phosphate in specified proportions of distilled water. The powdered ingredients for this solid film shall pass through a 325-mesh sieve (44 µm.).

Mixing, application and cure: Both MLF-5 and MLF-9 must be continuously stirred during mixing, and the mixed lubricant solution must also be stirred in the container during spray application. The solid film must be applied as a fine mist spray, using a dry-nitrogen pressure source. The rate of application should be such that the film appears to dry on contact and no wet spot should appear. Individual coats or layers of film lubricant should be between 2.54 and 10.16 µm. (0.0001 and 0.0004 in.). Both MLF-5 and MLF-9 require sequential heat cure cycles, the maximum for MLF-5 is 149°C (300°F); for MLF-9 the maximum is 227°C (440°F).

Workmanship: When applied to parts and cured as specified, both MLF-5 and MLF-9 lubricants shall show no evidence of cracking, flaking, or other defects that adversely affect their intended use.

MIL-L-60326 (MU)(1): Lubricant, Fluorocarbon Toelomer Dispersion (For Use With Ammunition, NATO Code: None)

General characteristics: This specification covers a fluorocarbon lubricant dispersed in tridorotrifluoroethane (Freon) available in three types (I, II, and III). The solid content varies from 20% to 2.5%.

Uses: The materials covered by this specification are intended for use with ammunition. It also has good lubricity and antistick properties and can be used on metals, lather, elastomers, etc., as a lubricant or release agent.

SS-G-659a: Graphite, Dry (Lubricating, NATO Code: S-732)

General characteristics: This specification covers a powdered lubricating graphite free from any indications of caking or lumping which may be made from natural or manufactured graphite, unless otherwise specified. The graphite-carbon content must not be less than 95%. No particle size shall be larger than 149 μm. (100 mesh); 88% must be smaller than 74 μm. (200 mesh); and at least 60% must be smaller than 44 μm. (325 mesh).

Uses: Intended for use as a dry lubricant or to be compounded with oils and greases. As a dry lubricant, it may be applied by burnishing, spray, or dipping. It may also be compounded with resinous binders, alone or with other materials to form solid lubricants and composite lubricants.

Limitations: The powdered lubricant does not provide corrosion protection. It may be used over a wide temperature range. The powder must be free from abrasives or other undesirable impurities, and must not contain more than 2.5% ash or volatile matter.

MSFC SPEC-502: Lubricant, Dry Film, Ceramic, MLF-5, Preparation and Application of

This specification covers the requirements for the preparation and application of a LOX compatible dry film lubricant designed MLF-5. Included are: qualification of the facility and process, spray operator, and new raw materials used. MLF-5 dry film is available in two grades: Type I - heavy duty, long life; Type II - light duty, short life.

Facility and process approved: To obtain facility and process, the supplier must prepare a complete description of the method of compounding and applying the lubricant. Preparation of endurance test samples meeting specification requirements are also required. Reapproval is also required for significant changes in procedure, facility or changes in operating personnel or if procedure is not used within 3 months.

Raw material approval: Each new batch combination of raw materials (except distilled water) requires preparation of three endurance test samples meeting specification requirements.

Spray operator approval: Each new spray operator must demonstrate his skill in spraying parts with MLF-5 lubricant by preparing three endurance test samples that meet specification requirements. Reapproval of operator is required if more than 1 month occurs between spraying operations.

Preparation of parts: Specification requirements cover method of surface preparation prior to application of lubricants. These include machine finish, grit blast finish, and surface cleaning. Unless detailed drawing specify otherwise, the surface finish should be in the range of 4.06 to 7.62 x 10^{-7} m. (16 to 30 μin.) rms.

Preparation of MLF-5 lubricant: Specification included completely the quantity and quality of each ingredient in MLF-5 lubricant. This includes molybdenum disulfide powder, graphite powder, sodium silicate, gold powder, NPC turgitol nonionic, and distilled or deionized water.

Film thickness: Optimum thickness of MLF-5 lubricant depends on anticipated use and available clearance. Unless specified on detailed drawings, recommended film thickness should be between 1.02 to 3.05 x 10^{-5} m. (0.0004 to 0.0012 in.).

Film cure cycle: The applied lubricant shall be heat cured in a three-step cure cycle.

1. Heat at 80°C ± 5°C for 2 hr.
2. Heat at 149°C ± 5°C for 8 hr.
3. Reduce slowly from 149°C to ambient temperature.

Shelf life: MLF-5 lubricant not used within 5 days after mixing shall be discarded.

Intended use: This specification is intended for use in the preparation and application of MLF-5 lubricant to specified parts or components of space vehicles and associated equipment.

MSFC (Drawing); 50M60434: Lubricant, Dry Film, MLR-2 Preparation and Application of (NATO Code: None)

This specification covers the requirements for the preparation of parts and applications of dry film lubricating materials, designated MLR-2, that has low friction coefficients and the capacity of supporting high loads without penetration. This dry film lubricant is not compatible with LOX.

Preparation of parts: Specification requirements cover method of surface preparation prior to application of lubricant. These include machine finish, grit blast finish,and surface cleaning. The prepared surface should have a random surface finish of 4.06 to 6.10 x 10^{-7} m. (16 to 24 μin.) rms.

Preparation of MLR-2 lubricant: Specifications list the ingredients and quantities of each as well as the method of mixing MLR-2 lubricants. Materials used are: molybdenum disulfide powder, antimony trioxide powder, polyimide high temperature binder solution, xylene-xylol, and pyrrolidinone. Ingredients must be thoroughly mixed for 5 min. in a sealed high-speed blender.

Application and film thickness: MLR-2 lubricant must be continuously stirred in a special side outlet flask during application to prevent particle settling. The mixture shall be applied by an air brush spray using nitrogen on air (MSFL-PROC-404) and the parts to be sprayed shall be heated to 49°C to 60°C (120°F to 140°F) prior to spraying. Heat lamps are required to assure a dry surface and to accelerate evaporation of the film mixture. After spraying, part should be dried at ambient temperature for 10 to 20 min. Film thickness shall be as specified on the applicable detail drawing. Optimum film performance is usually obtained with a film thickness of 7.62×10^{-6} m. (0.003 in.).

Film cure cycle: After the applied film has dried at ambient temperature, it shall be cured by the following three-step cycle: (1) 93°C (200°F) for 1.0 hr., (2) 302°C (575°F) for 1.0 hr., and (3) remove and allow to cool to ambient temperature.

Intended use: This specification is intended for the use in preparation and application of MLR-2 lubricant to specified parts and components of space vehicles and associated equipment.

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APPENDIX C

TEST EQUIPMENT AND PROCEDURES

Falex Lubricant Tester

A. Apparatus

The Falex tester utilizes a rotating pin and V-block test configuration as shown in Figure 1. The Falex Lubricant Tester consists of a drive motor, loading mechanism, reaction-torque sensing system, and elapsed running time control unit with an automatic cutoff switch (see Figure 2). The control unit and cutoff device were designed and fabricated at Midwest Research Institute. This tester, which has been used throughout the solid lubricant industry, provides a means for evaluating the load carrying capability and the wear-life of a film at high loads.

B. Test Procedures

1. Life tests:*

a. Insert the solid film coated V-blocks in the recesses of the loading device.

b. Mount the solid film coated test pin in the test shaft and insert the brass shear pin.

c. Position the loading mechanism and turn the ratchet wheel by hand until the loading mechanism engages (indicated on the load gauge). Position the load applying arm and energize the drive motor until a gauge load of 1,334 N (300 lb.) is reached; remove the load applying arm and continue running for 3 min.; then increase the load to 2,224 N (500 lb.) using the load applying arm, and run for 1 min.

d. Apply loads in increments of 1,112 N (250 lb); run for 1 min. at each load until a 4,448 N (1,000 lb.) gauge load is reached on the 20,016 N (4,500 lb.) gauge. Maintain a 4,448 N (1,000 lb.) load and measure the time-to-failure.

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* Test procedure requirements of Federal Test Method Standard No. 791a, Method 3807.

C 1

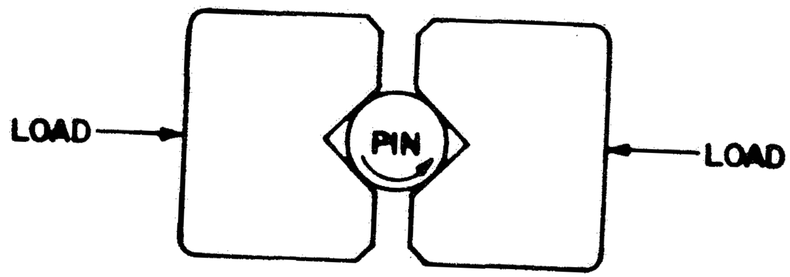

Figure 1 - Falex Test Configuration

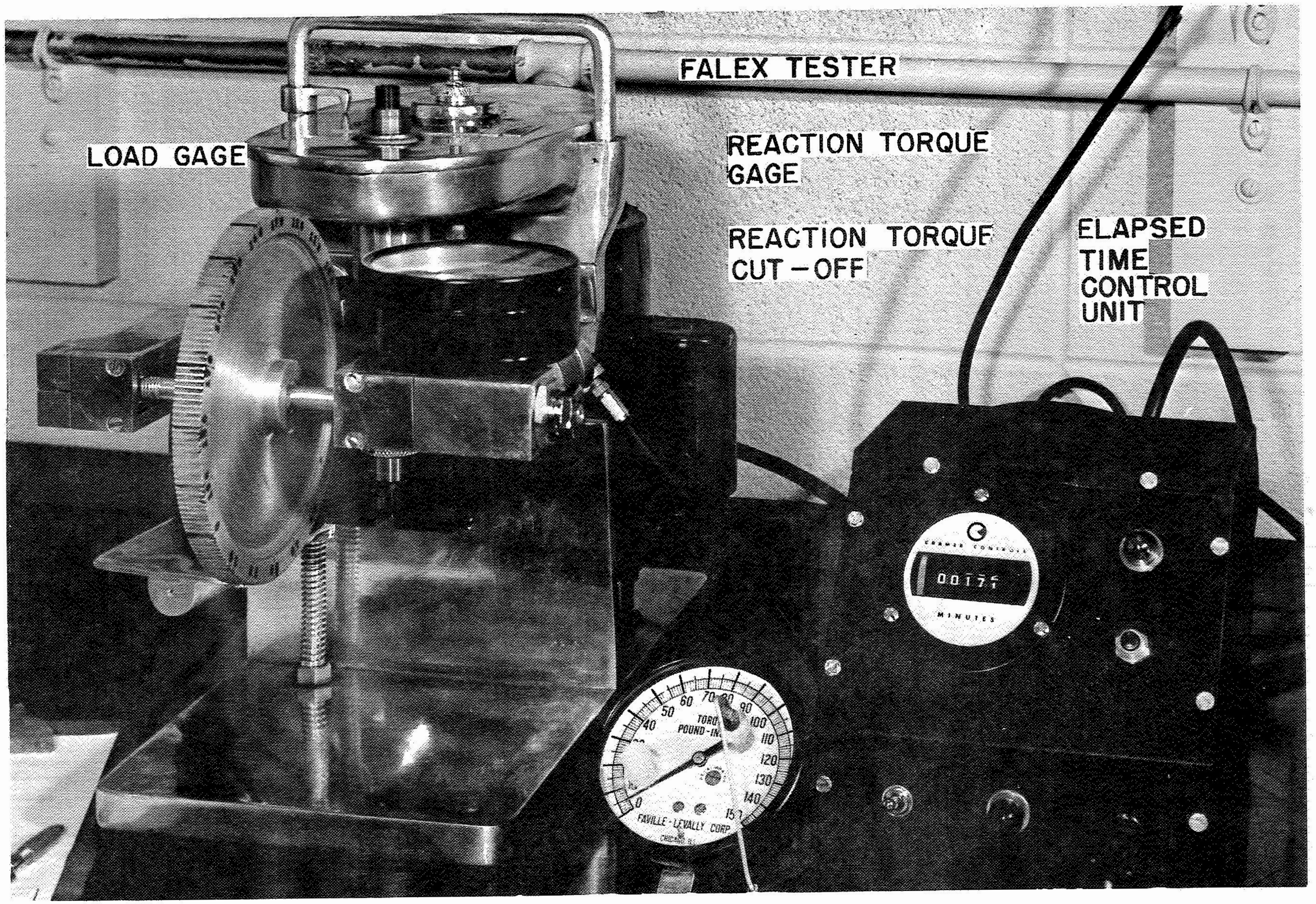

Figure 2 - Falex Tester With Torque Cutoff

e. Failure is indicated by a torque rise of 0.566 joule (5 in-lb) above the steady state value or breakage of the test or shear pin.

2. Load carrying capacity:*

a. Insert the solid film coated V-blocks in the recesses of the loading device.

b. Mount the solid film coated test pin in the test shaft and insert the brass shear pin.

c. Position the loading mechanism and turn the ratchet wheel by hand until the loading mechanism engages (indicated on the load gauge). Position the load applying arm and energize the drive motor until a gauge load of 1,334 N (300 lb.) is reached; remove the load applying arm and continue running for 3 min.; then increase the load to 2,224 N (500 lb.) using the load applying arm and run for 1 min.

d. Apply load in increments of 1,112 N (250 lb.) (gauge load) with 1 min. runs at each load until a gauge of 20,016 N (4,500 lb.)** is reached or until failure occurs.

e. Failure is indicated by inability of the lubricating film to maintain the load for 1 min., breakage of the shear or test pin, or a sharp increase in torque, 0.791 joule (7 in-lb or more) over the gradual increase accompanying the increase in load.

Vacuum Weight Loss of Bonded Solid Film Lubricants

Metal specimens, 1 in. x 1 in., were cleaned and coated with the test solid lubricant materials. All lubricant samples were cured in accordance with the manufacturer's requirements. Samples were then weighed on an analytical balance to the nearest 0.1 mg. Test samples were placed in holders and subjected to a vacuum of 1.3332×10^{-4} N/m^2 (10^{-6} torr) for a period of 528 hr. Samples were then reweighed and weight loss calculated on the basis of weight loss per square centimeter.

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* Test procedure requirements of Federal Test Method Standard No. 791a, Method 3812.

** Not required by Federal Test Method Standard No. 791a, Method 3812.

Electrical Conductivity

A. Apparatus

1. Glass slides, 0.0762 x 0.0254 m. (3 in. x 1 in.).

2. Silver paint.

3. Wheatstone bridge.

B. Test Procedure

1. Apply silver paint to the areas of the glass slide shown in Figure 3.

2. Apply and cure test lubricants in accordance with the manufacturer's requirements to areas shown in Figure 3.

3. Connect leads to silvered areas of slide and to Wheatstone Bridge.

4. Determine resistance of films and report results in ohms resistance for a 1-in. gap.

Pellet Wear-Life

A. Apparatus

The wear-life runs were performed on a 12-station bench setup (Figure 4). Each station consists of a wear-life tester and a control unit. The lubrication film was applied to the flat ends of the three pellets which are rigidly mounted in the pellet holder. The pellet holder, was driven at 900 rpm (765 fpm) and loaded to 2.94 N (300 g/contact), 93,079 N/m^2 (13.5 psi projected area). Film thickness was controlled between 1.01 and 1.52 x 10^{-5} m. (0.0004 and 0.0006 in.) for the resin-bonded films and 2.29 and 2.79 x 10^{-5} m. (0.0009 to 0.0011 in.) for the silicate-bonded films. A controlled flow of dry nitrogen was supplied to each station for the duration of each run.

The atmosphere was selected because it was inert, easily reproduced, and offered the possibility of correlation with vacuum environment data. The high friction shutoff switch was set so that the tester would shut down when the frictional torque reached a value corresponding to a frictional coefficient of 0.3 (Figure 5).

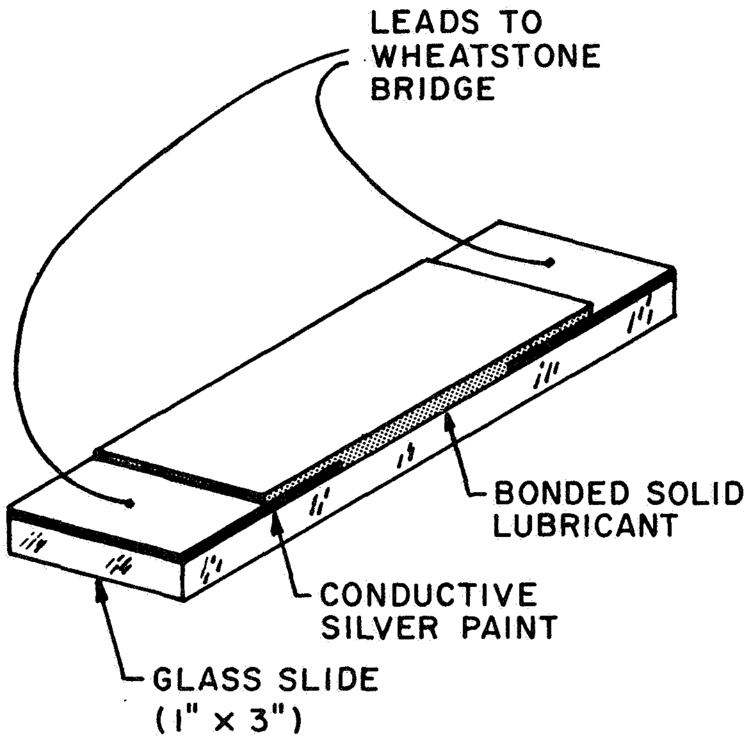


Figure 3 - Electrical Conductivity Apparatus

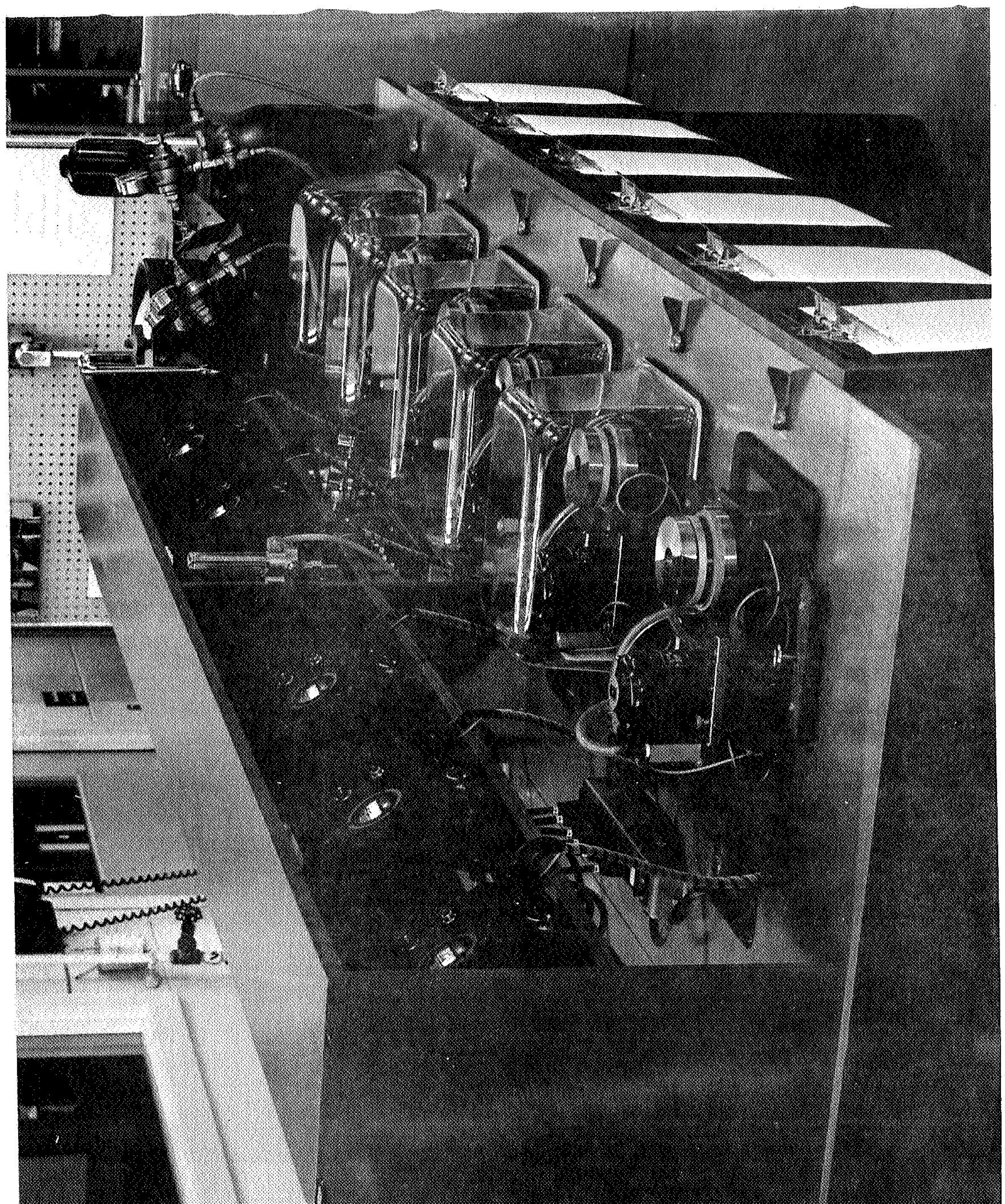


Figure 4 - Wear-Life Testers - 12 Stations

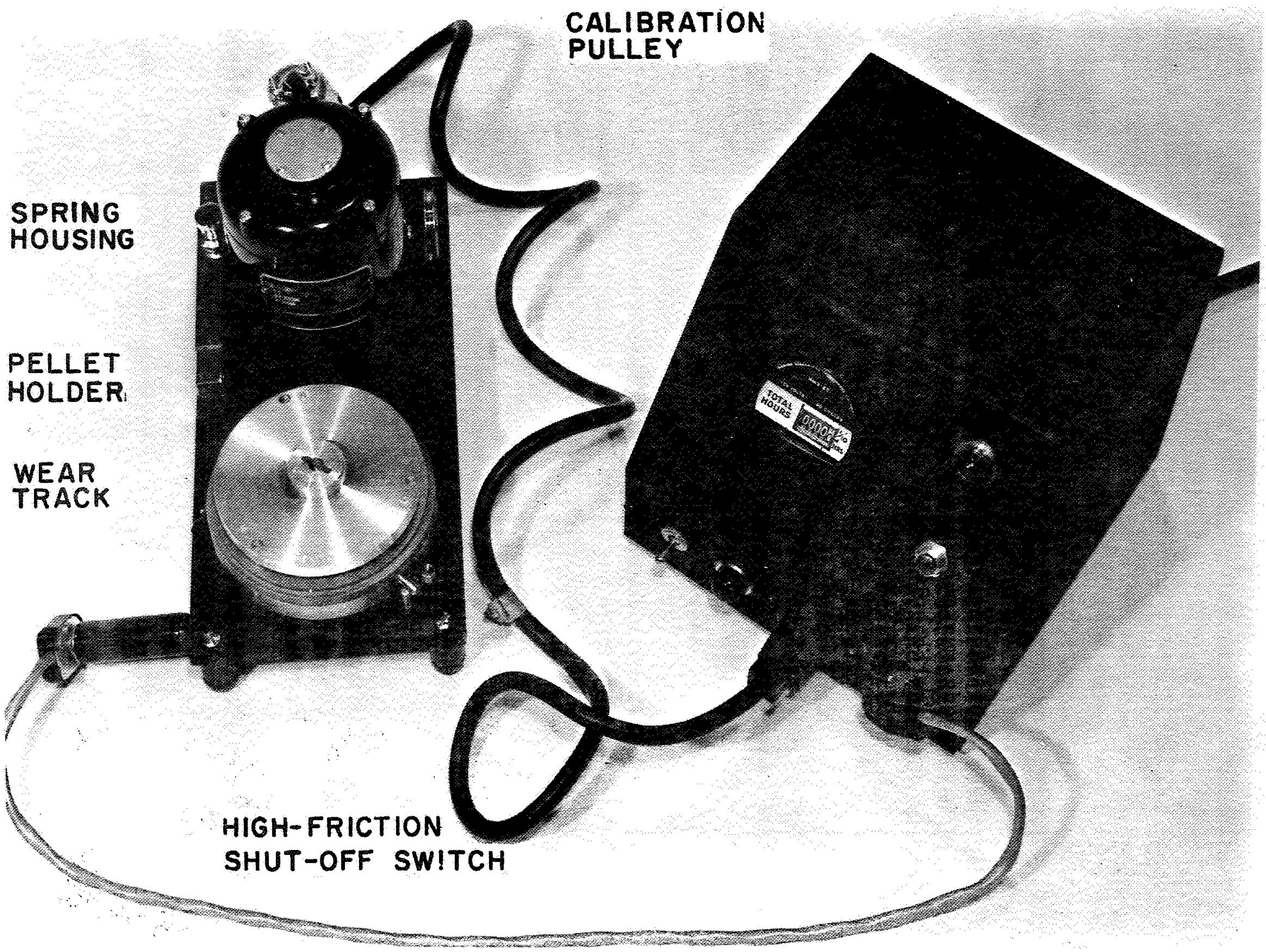


Figure 5 - Wear-Life Tester and Control Unit

The pellets were annealed, 440-C stainless steel, 0.00635 m. (0.25 in.) diameter by 0.00635 m. (0.25 in.) length, and the wear plates were hardened 440-C stainless steel (Figure 6). The hardness of the 440-C stainless steel was 15 to 20 Rockwell C in the annealed condition and 55 to 59 Rockwell C in the hardened condition.

B. Test Procedure

1. All commercial solid lubricants were applied and cured in accordance with the manufacturer's requirements.

2. Film thicknesses were measured to the nearest 2.54×10^{-6} m. (0.0001 in.).

3. Samples were then run for 10 min. at no load. This was done to smooth the film and transfer a thin film to the wear track.

4. Film thickness measured.

5. Item (3) was repeated under half load (150 g.) for 10 min.

6. Film thickness measured.

7. Full load of 300 g. applied to tester.

8. Tests terminated when friction reached 0.3.

Pellet Friction and Wear-Life (Environment)

A. Apparatus

The vacuum friction apparatus consists primarily of a dynamometer mounted, variable speed motor, fed into a vacuum chamber by means of a magnetic coupling. A wear track and pellet holder are placed on a pedestal inside the chamber and the pellet holder is driven by means of a drive pin inserted in the drive shaft (Figure 7).

Frictional torque is sensed by means of a transducer which sends a signal into a Bausch & Lomb strip recorder. The recorder is equipped with a variable over-torque shutoff switch and a clock timer measures the elapsed running time. The system is equipped with a mechanical vacuum pump and an oil diffusion pump. The test configuration is shown in Figure 6.

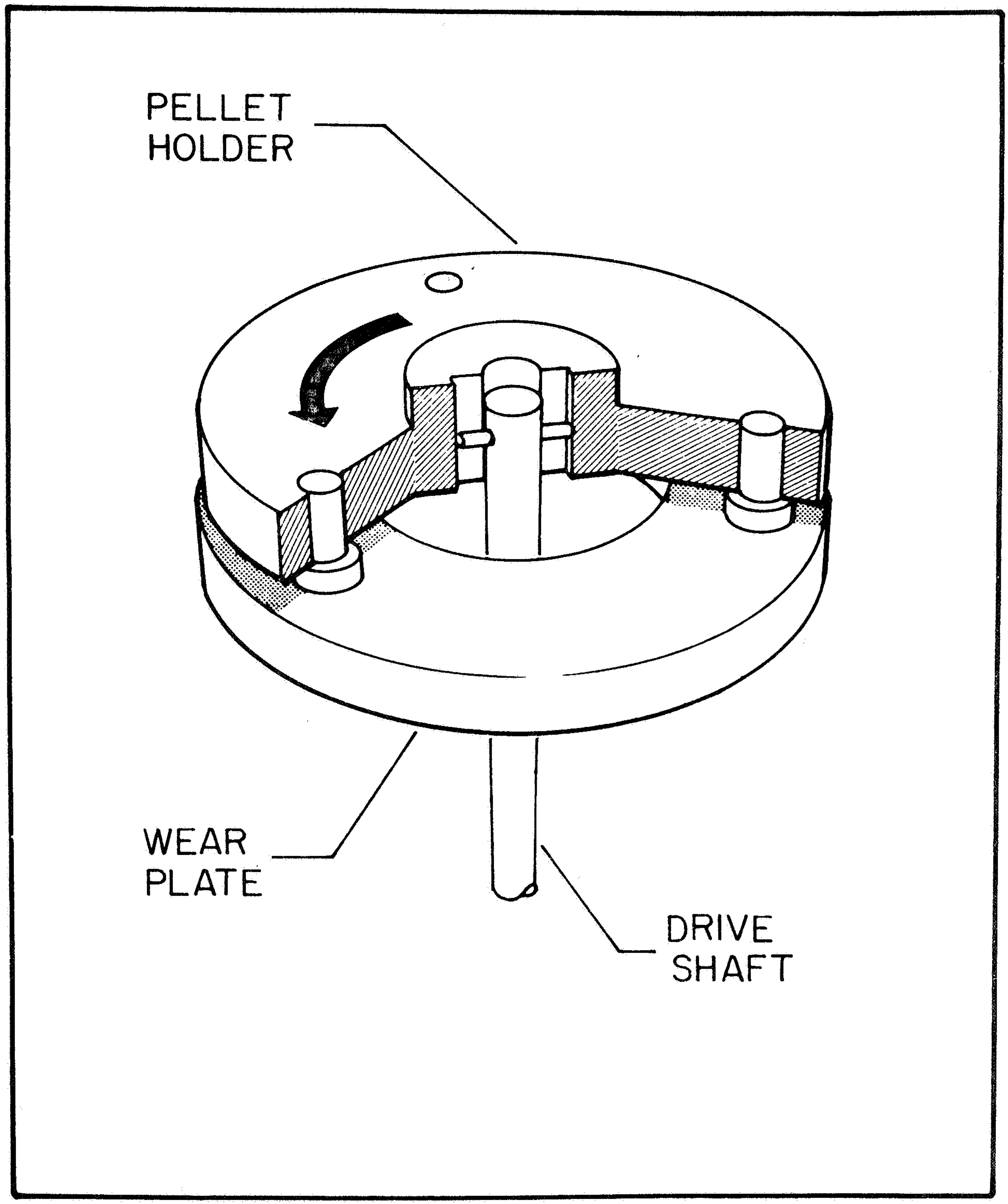


Figure 6 - Wear-Life Test Configuration

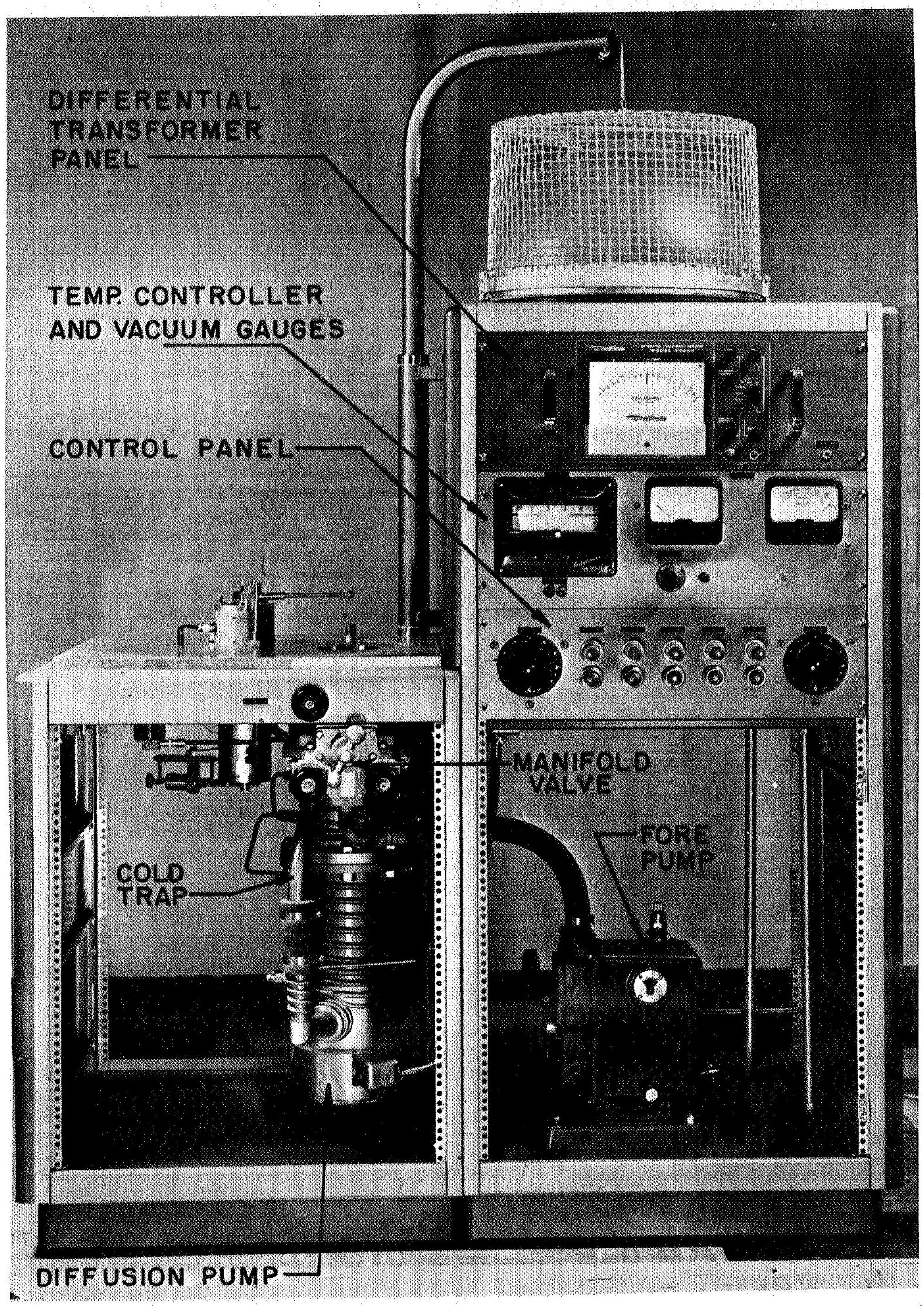


Figure 7 - Vacuum Friction Apparatus

All tests were conducted at 0.49033 N (50.0 g.) contact 15,168 N/m^2 (2.2 psi projected area), 900 rpm (765 fpm). The environment for these tests was ambient to 6.667 x 10^{-5} N/m^2 (5 x 10^{-7} torr).

The pellets were annealed, 440-C stainless steel, 0.00635 m. (0.25 in.) diameter by 0.00635 m. (0.25 in.) length, and the wear plates were hardened, 440-C stainless steel. The hardness of the 440-C stainless steel was 15 to 20 Rockwell C in the annealed condition and 55 to 59 Rockwell C in the hardened condition.

Test lubricants were applied and cured in accordance with the manufacturer's requirements. Films ranged in thickness from 1.01 and 1.52 x 10^{-5} m. (0.0004 to 0.0006 in.) for the resin-bonded materials to 2.29 and 2.79 x 10^{-5} m. (0.0009 to 0.0011 in.) for the silicate type materials.

B. Test Procedures

1. -100°F tests: The -100°F friction tests were accomplished by passing liquid nitrogen through the coils in contact with the wear track. Tests were conducted in vacuum to prevent the formation of ice on the wear track. Tests were started under full load 0.49033 N (50.0 g.). Static friction was measured at test start-up. Dynamic friction was monitored during the entire test. Tests were terminated when the coefficient of friction reached a value of 0.3.

2. Room temperature tests (ambient): Tests were conducted as described above except no cooling was required. Tests were conducted in dry-nitrogen atmosphere.

3. High temperature tests, 204°C (400°F): Tests were conducted as described in (1) and (2) above except heat was applied to maintain the 204°C (400°F) temperature. Tests were conducted in dry-nitrogen atmosphere.

Journal Bearing Tests

A. Apparatus

The journal bearing tester, shown in Figure 8, is used to measure coefficients of friction and wear-life of bonded solid lubricants applied to plain journal bearings operating on cylindrical shafts. The test shafts, Figure 9, are hardened dowel pins chucked in two precision collets mounted in pillow blocks. The journal is the base of a standard, 1.58 x 10^{-2} (5/8 in.) diameter spherical bearing. The spherical surface is used only

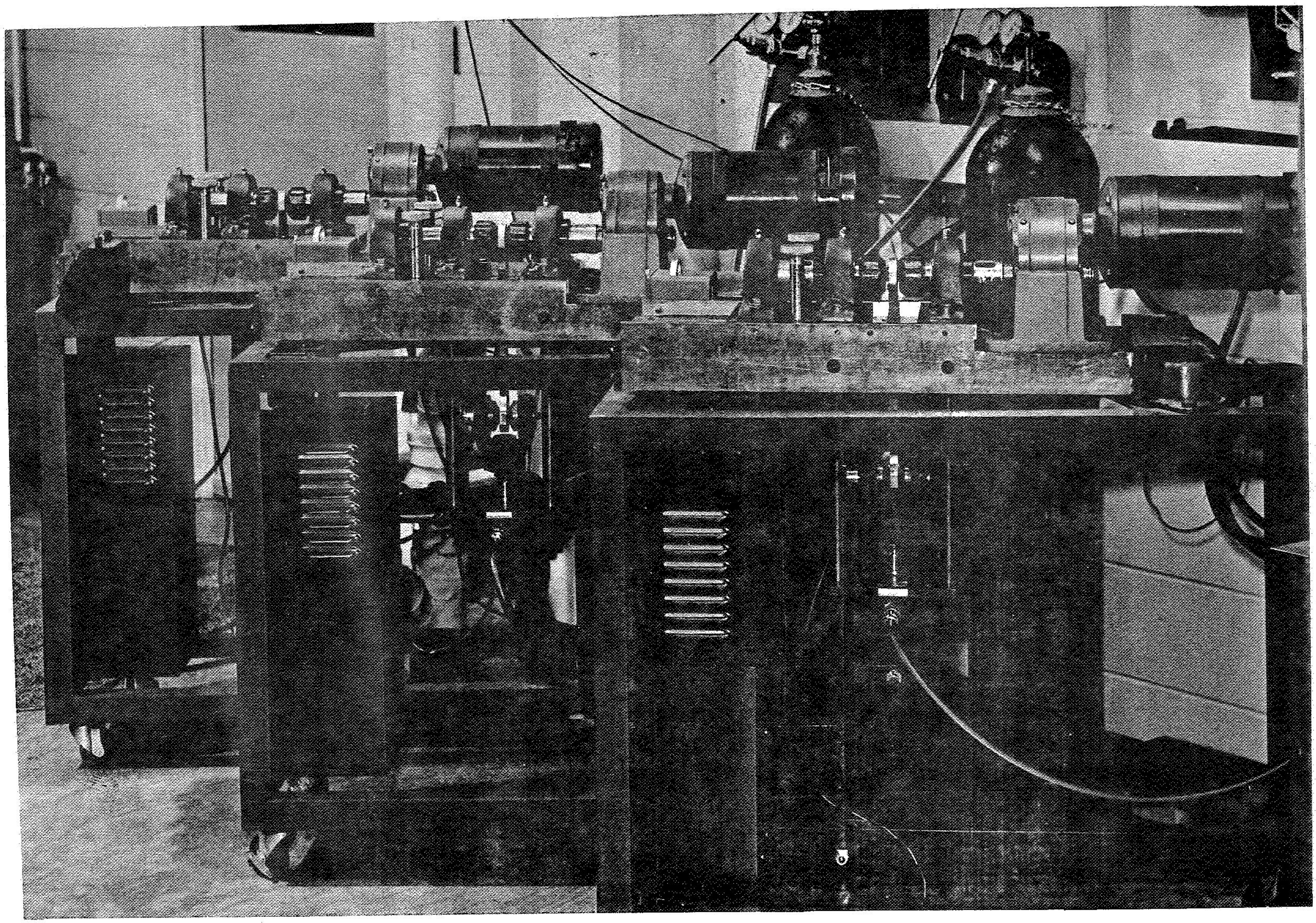


Figure 8 - Journal Bearing Test Machines

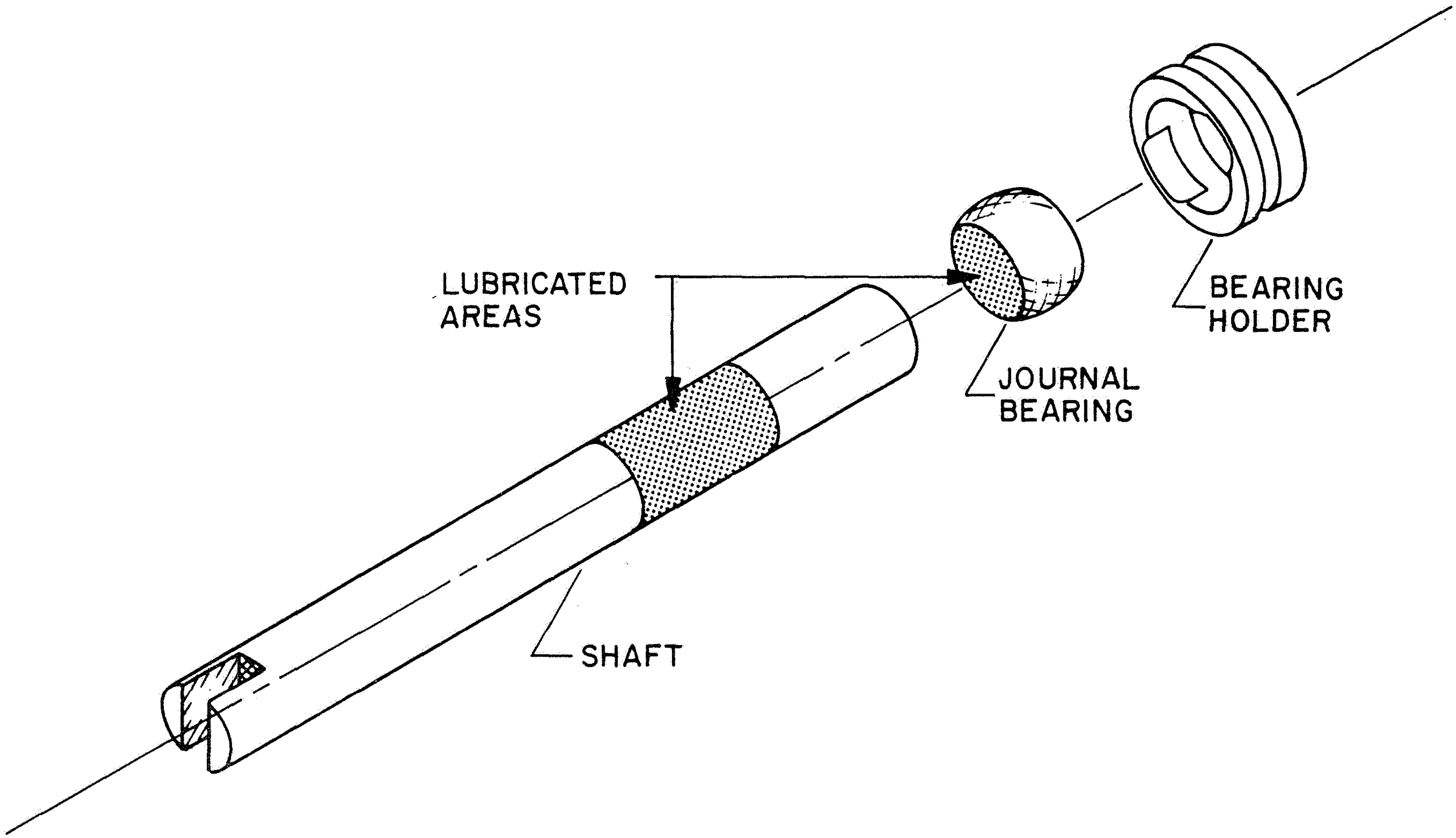


Figure 9 - Journal Bearing Test Specimen Configuration

for initial alignment and is not lubricated. A loader slot, spherical bearing seat is used to facilitate replacement of the journal. Load is applied to the journal by a 0.127 m. (5 in.) bore pneumatic cylinder through a hanger in which the spherical bearing seat is mounted. Regulated air or nitrogen is used to control the load on the journal bearing. The load hanger is instrumented with semi-conductor strain gauges for measurement of both load and torque.

One of the collets holding the shaft is driven by an SCR controlled DC motor with integral gear reducer. Shaft speed is adjustable from 5 to 100 rpm. A running time meter on the motor controller provides a measure of the wear-life of the journal bearing.

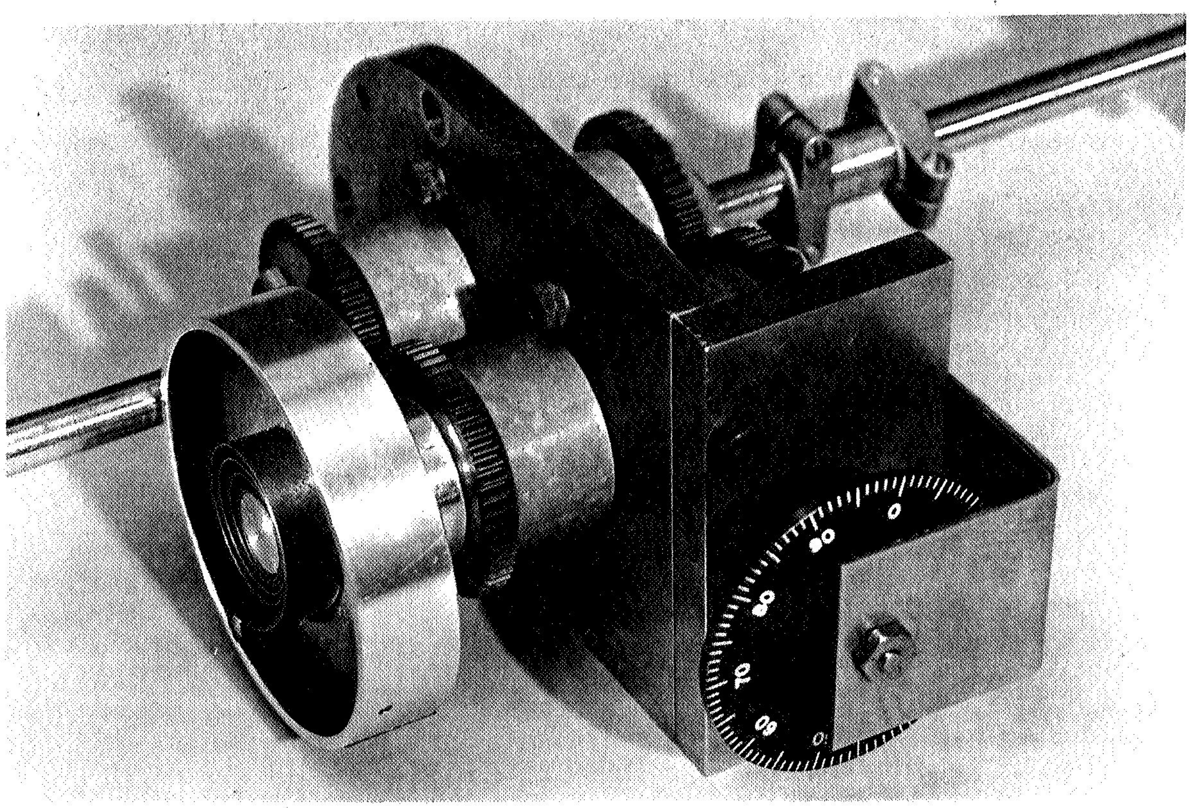
Torque sensed by the strain gauges is indicated on a meter relay and recorded on an external recorder. The meter relay is used to turn off the drive motor when a preset torque limit is exceeded.

B. Test Procedure

1. Assemble coated test specimens in the machine.
2. Tighten holding collets.
3. Set gas regulators for desired load.
4. Set the machine for desired test speed.
5. Connect gas hoses to pneumatic load cylinders.
6. Reset timer to zero minutes.
7. Set automatic shutoff at desired maximum friction.
8. Start test machine.
9. Run test until failure.

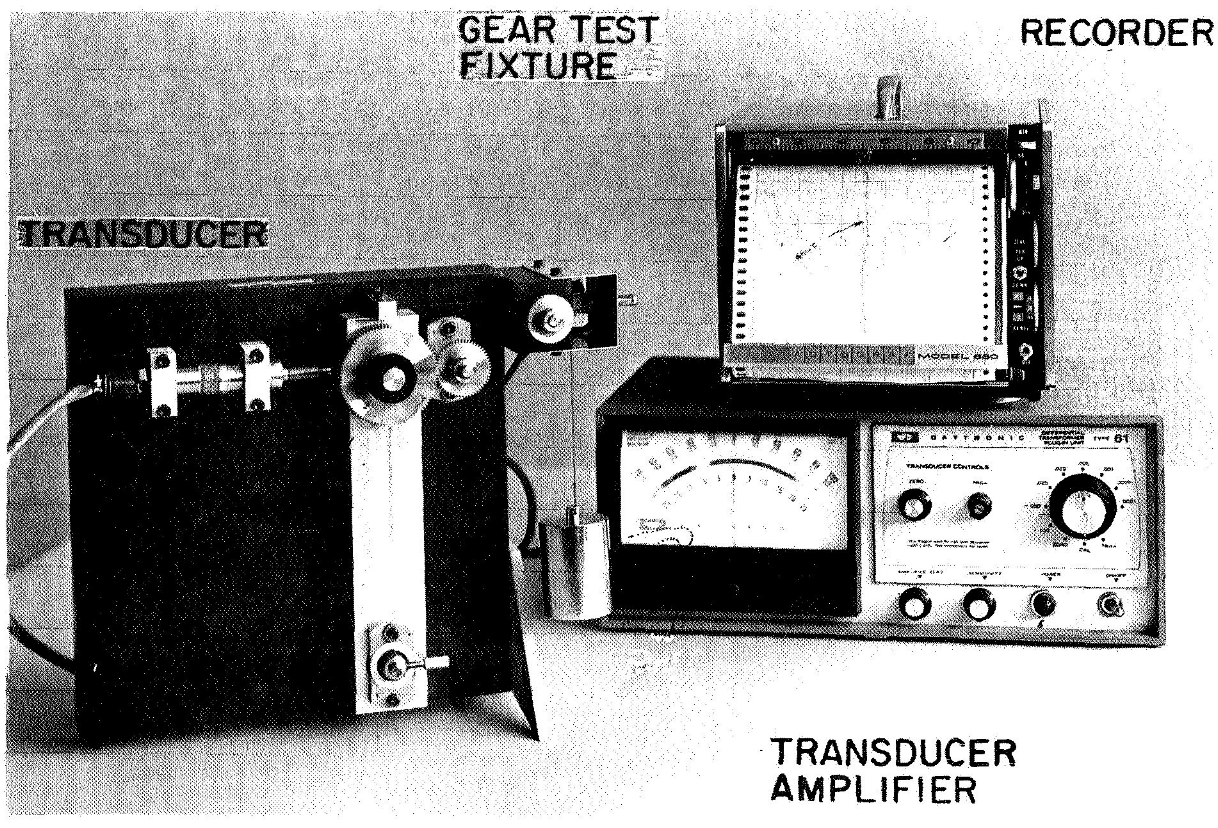
FOUR-SQUARE INSTRUMENT-GEAR TEST APPARATUS

The purpose of this apparatus is to evaluate solid film lubricant applied to instrument size spur gears. The test head is shown below. In this unit, torque loads to 20 oz-in are locked into the four square arrangement and the gears are driven at selected speeds between 50 and 5,000 rpm. Two of the 48-pitch 20-degree pressure angle test gears have 55 teeth and the other two have 56 teeth. The 55-tooth gears have a pitch diameter of 1.1458 and 1/8-in. face width. The 56-tooth gears have pitch diameters of 1.1667 and a face width of 3/16 in. This test head is one of six in a test setup which permits operation in air or inert gas. In addition, the test head is driven through a magnetic coupling to facilitate installation on a 4-or 6-in. vacuum flange for gear lubricant testing in a vacuum.



COMPOSITE GEAR MEASURING APPARATUS

The purpose of this apparatus is to: (1) measure tooth-to-tooth errors (variation in circular pitch, tooth thickness, and profile); (2) measure total composite error (total tooth and run-out variations); and (3) measure solid lubricant film thickness applied to the teeth. The composite gear measuring fixture consists of a calibrated master gear mounted on a movable arm, a linear displacement transducer, a transducer indicator amplifier, a strip chart recorder, and a drive motor for the test gear. The gear being tested is mounted on the driven shaft and loaded against the master gear with a 20-oz. weight. The changes in center distance as the two gears revolve are detected by the transducer which bears against the movable arm carrying the master gear. While the test gear is rotated through one complete revolution, the variation in center distance is recorded on the chart recorder.



<u>Test Procedure: Four-Square Gear Tester (Instrument Gears)</u>

1. Clean one set of test gears (four gears): (a) wash in detergent; (b) rinse with water; (c) rinse with acetone; and (d) dry with nitrogen.

2. Determine profile of each test gear using a variable center distance composite gear measuring apparatus tester. (Applies to Step 5.)

3. Prepare test gears for lubricant application by grit blasting with air carrier to obtain 15-25 rms surface finish. Clean test gears by: (a) detergent scrub; (b) ultrasonic cleaning with detergent; (c) water rinse; (d) acetone rinse; and (e) dry with nitrogen.

4. Apply dry film lubricant and cure.

5. Obtain profile of lubricated gears with gear tester. Determine lubricant film thickness by comparing before- and after-lubrication profiles.

6. Install gears in test fixture and adjust center distance for 0.0012 in. clearance (manufacturer's recommendation).

7. Run gears for 10 min. without load. Reset center distance to 0.0012 in.

8. Apply desired test load and evacuate and back-fill test chamber with nitrogen. Start drive motor and set speed at desired value.

9. Measure drive motor torque and set over-torque leaf spring to shut off at 25% increase in torque.

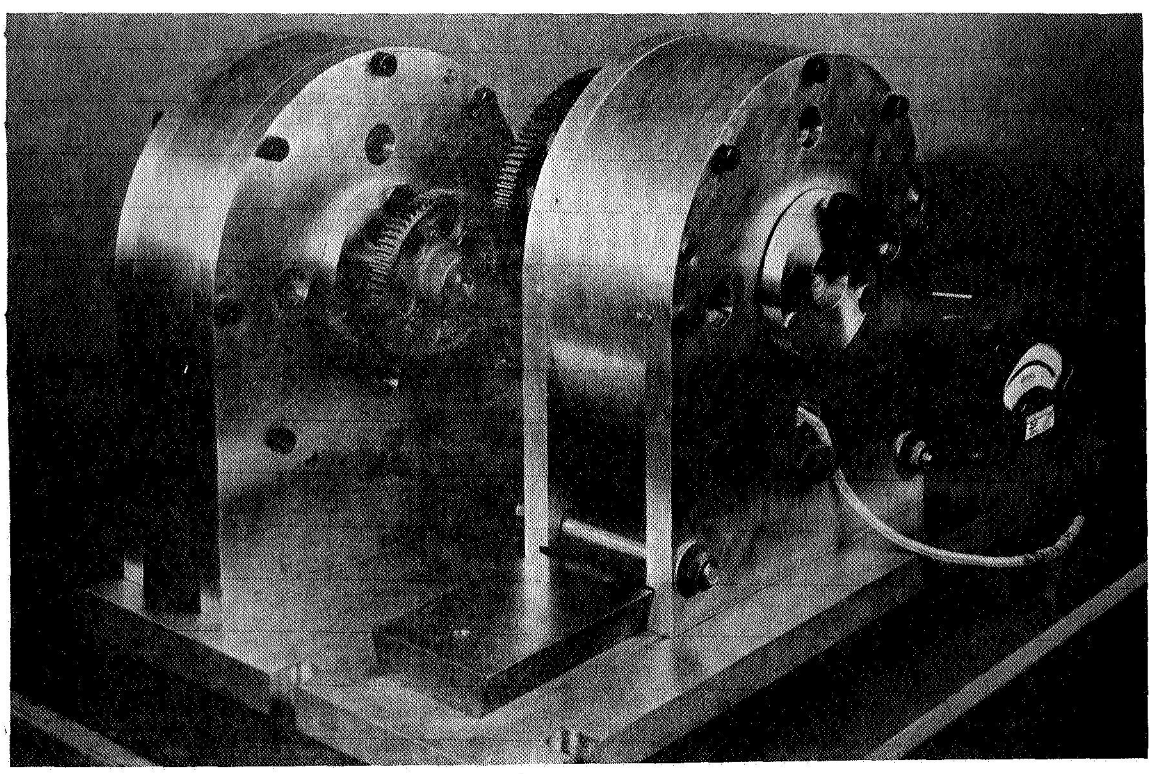
10. Allow test to run until failure occurs.

POWER-TRANSMITTING GEAR TEST APPARATUS

The spur gear test apparatus is used to evaluate films and composite materials on gears large enough to be considered as power-transmitting rather than instrument gears. Two DC torque motors, which provide constant torque at a given speed, are mounted so that the center distance between their shafts can be varied from 4 in. to 12 in. One motor serves as the driver and the other loads the gears. These functions are reversible and interchangeable. Test gears are mounted directly on the rotor shafts and may be of 10-20 diametral pitch. Performance data of the motors are:

	Motor 1	Motor 2
Maximum torque (ft-lb)	22	7
No load speed (rpm)	153	258
Maximum voltage (volts DC)	67.0	45.7
Maximum current (amp)	7.8	5.4

The motors are cooled by a forced draft and, when desired, the atmosphere surrounding the test gears may be controlled.



Test Procedure: Power-Transmitting Spur Gear Tester

1. Grit blast one set of test gears (two gears) with air carrier to obtain 12-25 rms surface finish. Clean gears by: (a) detergent scrub; (b) ultrasonic cleaning with detergent; (c) water rinse; (d) acetone rinse; and (e) dry with nitrogen.

2. Apply dry film lube and cure.

3. Install test gears on tester.

4. Adjust center distance to desired value.

5. Turn on cooling air to drive and load motors.

6. Start drive motor and adjust speed to 150 rpm.

7. Increase current on loading motor until desired load is obtained. NOTE: Do not exceed 3.9 ft-lb (3.0 amp) on load motor.

8. Allow test to run until lubricant failure is determined by visual observations of gear teeth. (Stop tester and examine gears every 1/2 hr.)

WORM GEAR TESTER

The purpose of the worm gear tester is to evaluate solid film lubricants applied to fractional horsepower worm gears. The tester consists of a 1/2 h.p. drive motor, the worm gear unit, and a 1/2 h.p. DC generator used as a loading device. The worm gear unit is a commercial 1/2 h.p., 10 to 1 reduction unit. The worm is case-hardened steel, with four threads and a 20-degree pressure angle. The worm wheel is brass with 40 teeth. Lubricant film is applied to both the worm and worm wheel. Both the drive motor and loading generator are dynamometer mounted to measure input and output horsepower. Worm temperature is monitored by a thermocouple in the shaft and tooth contact temperature is measured with an optical pyrometer.

Test Procedure: Worm Gear Tester

1. Clean one set of test gears (one worm gear and one worm wheel): (a) wash in detergent; (b) rinse with acetone; and (c) dry with nitrogen.

2. Install test gears in tester and connect drive motor and loading generator.

3. Lubricate the gears with 600 w. heavy-duty gear-box lube, start the drive motor, increase load until input is 0.28 h.p., and allow gears to run in for 30 min.

4. Drain oil from gear box and mark gears for proper indexing. Remove gears from tester.

5. Girt blast gears with air carrier to obtain 15-25 rms surface finish. Clean gears by: (a) detergent scrub; (b) ultrasonic cleaning with detergent; (c) water rinse; (d) acetone rinse, (e) vapor degreasing with Freon solvent; and (f) dry with nitrogen.

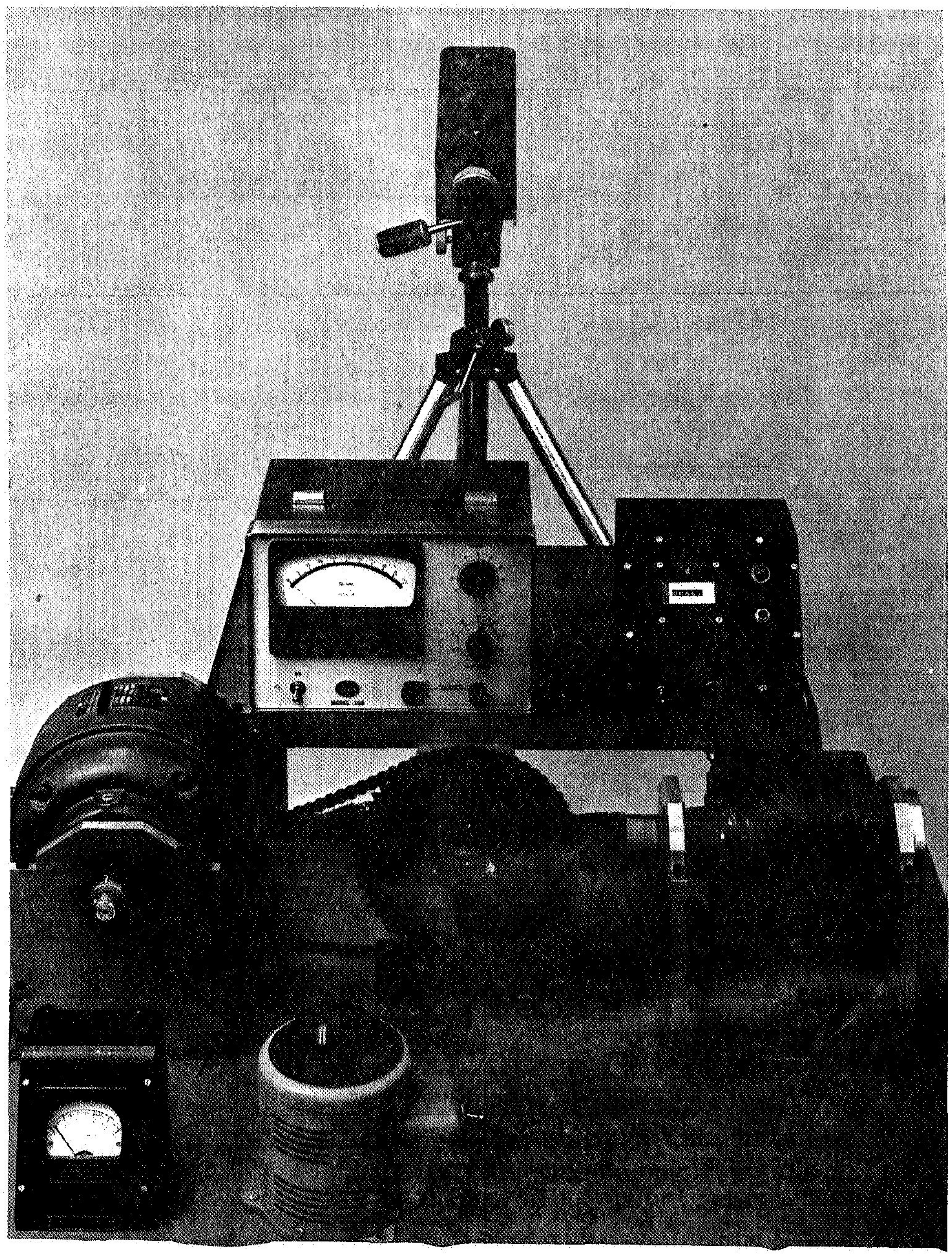
6. Apply dry film lubricant and cure.

7. Install gears in tester with index marks aligned and connect drive motor and loading generator.

8. Start drive motor and run-in gears for 10 min. at no load while brushing loose MoS_2 over worm gear.

9. Increase load to require 0.1 h.p. input. Record input and output torques. Repeat in 0.1 h.p. steps up to 0.6 h.p. and back to no load. Allow unit to operate 1 min. at each load level.

10. Adjust load to require 0.28 h.p. input and record output torque. Allow test to run until output torque increases 25% or until severe fluctuations (± 50% of average) occur in output torque.



PART B - LIQUID LUBRICANTS

BI - INTRODUCTION

I. INTRODUCTION

In the design and maintenance of mechanical systems, lubrication is as important as bearing loads, speeds of rotation, torque and serviceability. Lubrication is not an exact science, but rather a technology that has been developed through service experience. Consequently, little effort has been made to systematically arrange the physical, chemical and use properties of liquid lubricants such that designers, maintenance workers and others can conveniently obtain the information needed for their work. The intent of Part B of this handbook is to provide information on liquid lubricants that will be helpful in selecting a suitable lubricant for various applications.

The material in this handbook is intended as a general aid to the designers of spacecraft and ground support equipment. This book is not intended to supplant other publications or expert opinion on such special problems as corrosion protection, LOX and fuel compatibility, or compatibility of lubricants with various elastomers and plastics.

Users of the information presented are urged to contact the Materials Division of the Propulsion and Vehicle Engineering Laboratory, Marshall Space Flight Center, for aid in selecting liquid lubricants for special applications.

A. Description of Handbook

The handbook is divided into four separate sections: (I) Introduction; (II) Lubricant Descriptions; (III) Lubricant Data Sheets, and (IV) Appendix.

Section I, the introduction includes the cross index, lubricant applications guide and a description of how to use the handbook. The above mentioned cross index has been devised to aid the reader in matching trade names to military specifications. This index is comprised of two separate parts. The first part is arranged alphabetically by manufacturer's designations in the areas of oils, greases, hydraulic fluids and compounds. The second is a numerical listing by military specifications.

Section II, lubricant descriptions, contains written descriptions of specification materials listed in the document in ascending numerical order in the categories of oils, greases, hydraulic fluids and compounds.

Section III, lubricant data sheets, is comprised of data sheets covering physical and chemical properties for all of the materials listed. In addition, there are several pages giving special uses of fluids and typical viscosity versus temperature curves for a variety of fluid materials.

Section IV, the Appendix, contains a glossary of terms used in lubrication as well as brief descriptions of test methods used to determine physical and chemical properties of both grease and oil lubricants.

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LUBRICATING OILS AND FLUIDS

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII	Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Aeroshell Fluid 12	MIL-L-6085	21-22	American Supermil Motor Oil	MIL-L-2104	6,8,10
Aeroshell Fluid 5L	MIL-L-6086	23	Anderol L 401D	MIL-L-6085	21-22
Aeroshell Fluid 5M	MIL-L-6086	23	Anderol L 416	MIL-L-3918	17
Aeroshell Oil	MIL-L-6082	19	Anderol L 751	MIL-L-25681	49
Aeroshell Oil 100	MIL-L-6082	19	Anderol L 826	None	67-68
Aircraft Engine Oil 1065	MIL-L-6082	19	Apiezon	None	55
Aircraft Gear Oil - Grade L	MIL-L-6086	23	Atlantic Grade 1100 (No. 43600)	MIL-L-6082	19
Aircraft Gear Oil - Grade M	MIL-L-6086	23	Atlantic MIL-L-2104B Oil	MIL-L-2104	6,8,10
Aircraft Gear Oil EP - Light	MIL-L-6086	23	Atlantic Turbo Oil	MIL-L-7808	25-26**
Aircraft Gear Oil EP - Medium	MIL-L-6086	23	Atlantic Ultragear Oil	MIL-L-2105	14-16
Aircraft Oil 120-3120	MIL-L-15016	35**	Atlantic 2110, 2135	MIL-L-15016	35-37**
Algol Oil	MIL-L-26087	50**	Atlantic 1229, 1264, 28467	MIL-L-15016	36-37
			Atlantic 3050, 3065	MIL-L-15016	37
American Multi-Purpose Gear Lubricant No. 80	MIL-L-2105	11	Atlantic 9110, 9170, 9250	MIL-L-9000 (Ships)	30**
American Multi-Purpose Gear Lubricant No. 90	MIL-L-2105	11	Atlantic 9500	MIL-L-9000 (Ships)	29-30**
			Atlantic 31100, Grade 1010	MIL-L-6081 (ASG)	18
American Multi-Purpose Gear Lubricant No. 140	MIL-L-2105	11	Avrex 101/1065, 101/1100	MIL-L-6082	19-20
American S-3 Motor Oil SAE 10W	MIL-L-45199	51	Brayco 300	VV-L-800	1-2
			Brayco 363	MIL-L-7870	27
American S-3 Motor Oil SAE 30W	MIL-L-45199	5			

* Caution, trade names and commercial designations may be obsolete. New qualified products lists were not available for this revision.
** Product conforms to specification but is not listed on page indicated.

LUBRICATING OILS AND FLUIDS (Continued)

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Brayco 421, 423, 425	MIL-L-2104	8-10**
Brayco 441, 443, 445	MIL-L-21260	41-45
Brayco 450	None	57
Brayco 460	MIL-L-6081 (ASG)	18**
Brayco 480R	MIL-L-6082	19-20
Brayco 707	None	58
Brayco 810-13	None	65
Brayco 830	None	67-68
Brayco 880R	MIL-L-7808	25-26**
Brayco 885	MIL-L-6085	21-22
Brayco 899G, R, S	MIL-L-23699 (WEP)	48
Brayco NPT-5	None	67
Calol (MIL) 9110, 9170, 9250, 9500	MIL-L-9000 (Ships)	30
Calol 4065	MIL-L-15019	39-40
Calvis 300	VV-L-825a	3
Campella, Oil D	VV-L-825a	3
Camproil 11	VV-L-825a	3
Capella 2075	MIL-L-15016	35-37**
Cellutherm 2505A, 2505B	MIL-L-9236 (USAF)	31
Cetus 2110	MIL-L-15016	35

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Citgo Anti-Corrode 107-SAE 10	MIL-L-21260	41-42
Citgo Anti-Corrode 107A-SAE 30	MIL-L-21260	43-44
Citgo Aviation Oil 1065; 1100	MIL-L-6082	19-20
Citgo Prem. Gear Oil (MP)-90; -140	MIL-L-2105	13-16
Citgo Sentry G-2110, G-2190	MIL-L-15016	35-36
Citgo Sentry	MIL-L-15016	35-37
Citgo C-510	MIL-L-45199	51-54
Citgo 6086-L, 6086-M	MIL-L-6086	23-24
Citgo 93113	MIL-L-9000 (Ships)	29-30
Citgo 93116	MIL-L-2104	5-10
Conoco NS 3080, NS 3100, NS 3120, NS 3150	MIL-L-15016	35-37**
Conoco S-3, LC No. 42	MIL-L-45199	52
Conoco S-3, Diesel Oil	MIL-L-45199	54
Conoco 21260	MIL-L-21260	42
Cosmolube 263	MIL-L-7870	27
Cosmolubric 270A	MIL-L-6085A	22
Cosmolubric 677	MIL-L-26087	50

** Product conforms to specification but is not listed on page indicated.

LUBRICATING OILS AND FLUIDS (Continued)

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII	Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Deep Rock SHD-3	MIL-L-45199	52	Esso Aviation Oil 65, 1100	MIL-L-6082	19-20
Delta(E) 9110, 9170, 9250, 9500	MIL-L-9000 (Ships)	30	Esso Gear Oil GX-80, GX-90, GX-140	MIL-L-2105	11-16
Delvac, S-210, S-230	MIL-L-45199	52	Esso Turbo Oil 10	MIL-L-6081 (ASG)	18
Diamond 2075, 2110, 2135, 2190, 2250, 3080, 3100, 3120, 3150	MIL-L-15016	35-37**	Essolube D-3, 10W; D-3, 30W	MIL-L-45199	51-54
Dow Corning Silicone Fluids	None	135	Five Star 9110, 9170, 9250, 9500	MIL-L-9000 (Ships)	29-30**
Du Pont, Krytox 143 Fluids	None	71-72	Fomblin Y Fluorinated Fluids	None	61-62
Du Pont PR-143 Gas Turbine Oil	None	59	Formula No. 77675-5L, 6L, 7L, 8L	MIL-L-6082	19-20**
Du Pont, Freon Fluids	None	63	Franklin 2104B Motor Oil	MIL-L-2104	5-10
D-X Engine Preservative Oil No. 1	MIL-L-21260	42	Freedom 3100, 3120, 3150	MIL-L-15016	35-37**
D-X Engine Preservative No. 2	MIL-L-21260	44	Freon, E1, E2, E3, E4, E5	None	63
D-X Marine 9110, 9170, 9250, 9500	MIL-L-9000 (Ships)	30**	G. E. Silicone Fluids	None	133-134
D-X Motor Oil 9110, 9170, 9250, 9500	MIL-L-9000 (Ships)	30**	Golden Bear No. 2087	MIL-L-26087	50**
Eastman Synthetic Lubricant 15B	MIL-L-7808	25-26	Gulf Multi-Purpose Gear Lub. 80, 90, 140	MIL-L-2105	11-16
Enco Instrument Oil	MIL-L-7870	27	Gulf No-Rust Oil, Grade 1, Grade 2, Grade 3	MIL-L-21260	41-45
Engine Oil 3042(MIL Symbol)	MIL-L-15016	35-37**	Gulf Synthetic Lub. No. 2	MIL-L-007808 (USAF)	25-26
Engine Oil 9279, 9278	MIL-L-21260	41-45	Gulf Super Duty 10W, 30W	MIL-L-45199	51-54
			Gulf A-1100	MIL-L-6082	19-20

** Product conforms to specification but is not listed on page indicated.

LUBRICATING OILS AND FLUIDS (Continued)

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII	Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Gulf 9110, 9170, 9250, 9500, Y-2075, S-2110, S-2135, 2190, 2250, 3042, 3050, 3065, 3080, 3100, 3120	MIL-L-9000 (Ships)	29-30**	MacMillan Jet Engine Oil 1010	MIL-L-6081 (ASG)	18
			Marine Engine Oil 4065B,	MIL-L-15019	39-40
			Mobil DTE 103	MIL-L-26087	50**
Gulflite Turbojet Oil 1010	MIL-L-6081 (ASG)	18	Mobil Komo Engine Oil	MIL-L-15019	40
Gulflube Oil XHD SAE 10W	MIL-L-2104	5-10	Mobil RM 193A, RM 147A1	MIL-L-23699 (WEP)	48
Halocarbon Fluids	None	69-70	Mobil S600A, S600C, S600E, S645A, S645C, S645E	MIL-L-2104	6,8,10
Hatcol 3211	MIL-L-23699 (WEP)	48			
Humble Motor Oil 2083, 2085, 2087	MIL-L-2104	6,8,10	Motrex 317-SAE 80, -SAE 90, -SAE 140	MIL-L-2105	11,12,14,16
Humble EP Gear Oil 5420	MIL-L-2105	12	Multigear Lub. EP-80, -90, -140	MIL-L-2105	11-16
Infilrex 101, SAE 10W, 30W, 50W	MIL-L-21260	42,44	Multimachine Oil ICH 19	MIL-L-26087	50**
			Nator 825-11	VV-L-825a	3
Jet Engine Oil, Medium	MIL-L-6081 (ASG)	18			
Jet II	MIL-L-23699 (WEP)	46-48	Nator 2075, 2110, 2135, 2190, 2250, 3042, 3050, 3065, 3080, 3100, 3120, 3150	MIL-L-15016	36-37
Kendall KG-80	MIL-L-83176	64			
Kendall SRG-40, -60, -100	None	64	Nator 9110, 9170, 9250, 9500	MIL-L-9000 (Ships)	30
Kendex 7030, 7031, 7032,	MIL-L-21260	42,44,45	Neptune 1-Z	MIL-L-15019	40
Kendex 7042	MIL-L-6081 (ASG)	18	Nox-Rust 236	MIL-L-21260	41-45
Low Temperature Gear Lub. - Grade L & M	MIL-L-6086	23-24	Nox-Rust 518, Code R-62-203-1	VV-L-800	2
Low Temperature Oil 1692	MIL-L-7870	27	Nox-Rust 600	MIL-L-6085	22

** Product conforms to specification but is not listed on page indicated.

LUBRICATING OILS AND FLUIDS (Continued)

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Ocnus HD-2410, HD-2430	MIL-L-45199	52-54
Ped-3463-SAE 10, 3464-SAE 30	MIL-L-45199	51-54
Pennsylvania No. 4162	MIL-L-26087	50**
Penn Drake 4065-NS	MIL-L-15019	39-40
Pennzoil 3042, 3050, 3065	MIL-L-15016	35-37**
Pentalube TP 653-1B	MIL-L-9236	31**
Pentrolube 1010	MIL-L-6081 (ASG)	18**
Pentrolube 1065, 1100	MIL-6082	19-20
Petrotect 800	VV-L-800	1-2
Petrotect 21263	MIL-L-21260	45
Phillips 66 Aviation Oil, Grade 1065, 1100	MIL-L-6082	19-20
Phillips 66 HDS Oil (4414) SAE 10W	MIL-L-2104	5-10
Phillips 66 Super HD Oil	MIL-L-45199	51-54
Philube 66 Gear Oil SMP	MIL-L-2105	12,14,16
Posolube Series 3	MIL-L-45199	54
PQ Rust Preventive No. 172	VV-L-800	1-2
PQ Turbine Lubricant	MIL-L-7808	25-26**
Product 80	MIL-L-6085	21
Protexol Compound Oil	MIL-L-15019	40
Protexol Refrigerant Compressor Oil, Type II	VV-L-825a	3
P 010 K-8	MIL-L-6085	22
Red Line Z904 Oil	MIL-L-21260	42,44
Regal E-2190	MIL-L-15016	36
Richfield 2075, 2110, 2135, 2190, 2250	MIL-L-15016	36
Richfield B-4065	MIL-L-15019	40
Richlube RP Motor Oil	MIL-L-21260	44
R-Industrial Oil No. 17Z, No. 57Z	MIL-L-45199	52
Royco No. 2 Instrument Oil	None	73
Royco 308	VV-L-800	2
Royco 808RH	MIL-L-7808	25-26
Royco 808GF	MIL-L-7808 (USAF)	25-26
Royco 871	MIL-O-11773 (ORD)	34
Royco 885	MIL-L-6085	22
Royco 899	MIL-L-23699 (WEP)	46-48
Royco 81MS	MIL-L-25681 (ASG)	49

** Product conforms to specification but is not listed on page indicated.

LUBRICATING OILS AND FLUIDS (Continued)

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Selection BIII
RPM Aviation Oil 900	MIL-L-6082	19-20**
RPM Jet Engine Oil 1010	MIL-L-6081 (ASG)	18**
Rust Foil No. 2675	VV-L-800	2
Sato 5180	MIL-L-23699 (WEP)	48
Sentry G-2075, G-2110, G-2135, G-2190, G-2250, G-3042, G-3050, G-3065, G-3080, G-3100, G-3120, G-3150	MIL-L-15016	35-37**
Ser. 0-1065	MIL-L-6082	19
Servac 2075, 2110, 2135, 2190, 2250	MIL-L-15016	36
Shell Aircraft Turbine Oil 303	MIL-L-7808	25-26**
Shell Ensis Oil 212, 411, 412, 413	MIL-L-21260	42
Shell Rimula Oil SAE 10W, SAE 30W	MIL-L-45199	52-54
Shell Oil 2075, 2110, MS-2135	MIL-L-15016	35-37**
Shell Spirex HD 80, HD 90, HD 140	MIL-L-2105	11,12,14,16
Shell 9110, 9170, 9250, 9500	MIL-L-9000 (Ships)	30
Shellair Turbine Oil 510	MIL-L-23699 (WEP)	48
Shellmil B Oil	MIL-L-2104	6,8,10

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Sinclair Aircraft Turbo S Oil 15	MIL-L-7808	25-26**
Sinclair L-883	MIL-L-26087	50**
Sinclair MC-3042, HST-3050, HST-3065	MIL-L-15016	35-37**
Skelflite 65	MIL-L-6082	19-20
Sohio 4065 Compound	MIL-L-15019	40
Solvus 500	MIL-L-26087	50**
Standard Oil 2075Q, 2110Q, 2135Q, 2190Q, 2250Q, 3080N, 3100N, 3120N, 3150N	MIL-L-15016	36
Standard 9110, 9170, 9250, 9500	MIL-L-9000 (Ships)	30
Stauffer Jet 1	MIL-L-007807 (USAF)	25-26
Stauffer 3664	None	67
Sunoco Multi-Purpose Gear Lub. GL-4	MIL-2105	12,14,16
Sunoco Ocnus HD	MIL-2104	6,8,10
Sunoco 4065 Compound	MIL-L-15019	40
Sunvis 710B, 730B	MIL-L-21260	42-44
Sunvis 99-3080, 100-3100, 120-3120	MIL-L-15016	35-37**
Supermil Engine Oil No. 0119, 0719, 0529, 0059	MIL-L-9000 (Ships)	30

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LUBRICATING OILS AND FLUIDS (Concluded)

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Supermil Oil No. 2806	MIL-L-6082	19-20
Supermil Oil No. 06212	MIL-L-21260	41-45
Symbol MS 4065	MIL-L-15019	39-40
Synthetic Aircraft Turbine Oil 15	MIL-L-7808	25-26**
Tectyl 893	VV-L-800	1-2
Texaco Aviation Engine Oil 1065	MIL-L-6082	19
Turbine Oil 15	MIL-L-7808	25-26**
Turbo Oil 2380	MIL-L-23699 (WEP)	46-48
Turbo Oil 4040	MIL-L-7808	25-26**
TL-240-4065	MIL-L-15019	39-40
Ultramo Series 3	MIL-L-45199	51-54
Univis P-38	MIL-L-6085	21-22
Union MS-2190, MS-2250	MIL-L-15016	35-37**
Ursa Oil Extra Duty	MIL-L-2104	5-10
Ursa Oil Super Duty, SAE 10	MIL-L-45199	51-54
Ursa S-3, SAE 30	MIL-L-45199	51-54
Ursa Oil P-30, P-40, P-50, P-20	MIL-L-15016	35-37
Ursa 2250	MIL-L-15016	35-37**
Vac Kote 36218, 36233, 36234	None	56
Valvoline Jet Turbine Oil	MIL-L-7808	25-26**

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LUBRICATING GREASES

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII	Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Aeroshell Grease 2	MIL-G-18709	84**	Calomil Grease 121	MIL-G-18709	84
Aeroshell Grease 7A	MIL-G-23827	89-90	Chevron OHT Grease	MIL-G-18709	84
Aeroshell Grease 14	MIL-G-25537 (ASG)	93	Code ILC 22122	MIL-G-10924	82
Aeroshell Grease 15	MIL-G-25013	91-92	Code 12227	MIL-G-25537	93**
Aeroshell Grease 16	MIL-G-25760 (ASG)	95-96	Cosmolube 506	MIL-G-10924	82
Aeroshell Grease 17	MIL-G-21164 (ASG)	85-86	Cosmolube 615	MIL-G-4343	77-78
Aeroshell Grease 5	MIL-G-3545	75-76	Cosmolube 678	MIL-G-23827	89-90
Aircraft Starter Grease	MIL-G-7187	81	Cosmolube 5100	MIL-G-27549	94
Anderol L-237	MIL-G-6032	79-80	Cycleweld L-874	MIL-L-10924	82
Andok 260	MIL-G-3545	75-76	Dow Corning FS-1292	MIL-G-27617	97-98
Andok B	MIL-G-18709 (Navy)	84	Dow Corning 44 Grease	MIL-G-15719	83
Atlantic Lubricant 52	MIL-G-18709 (Navy)	84	Dow Corning 55M Grease	MIL-G-4343	77-78
Batco 1000, 2000	MIL-G-10924	83	Du Pont PR-240	MIL-G-27617	97-98
B & RB Grease No. 2, No. 3	MIL-G-18709 (Navy)	84	Dura Lube M-12B	MIL-G-10924	82
Braycote 632	MIL-G-6032	79-80	Electro-Moly/11	MIL-G-21164	85-86
Braycote 637	MIL-G-25537 (ASG)	93**	E-Z Turn Lubricant	MIL-G-6032	79-80
Braycote 643	MIL-G-4343	77-78	Grease TG-4971	MIL-G-25760	95-96
Braycote 645	MIL-G-3545	75-76	Grease XRR 3	MIL-G-23549	87
Braycote 660S	MIL-G-25760 (ASG)	95-96	Grease 22443	MIL-G-23549	87
Braycote 664	MIL-G-21164 (ASG)	85-86	High Temp. Grease	MIL-G-3545	75-76
			High Temp. Grease L-1231	MIL-G-3545	75-76

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LUBRICATING GREASES (Concluded)

Trade Name or Commercial Designations*	Specification No. If Qualified	Data Sheet Page No. Section BIII
HVI Microgel Grease No. 2	MIL-G-18709	84
International 22440	MIL-G-3545	75-76
Jet Hi-Temp. Grease	MIL-G-25013	91-92
Launch Pad Grease	MIL-G-23549 (ASG)	87
Micronic 803	None	34
Mobilgrease 24	MIL-G-25013	91-92
Mobilgrease 27	MIL-G-23827	89-90
Mobilplex	MIL-G-18709	84
Mobil XRR-38	MIL-G-81322 (WP)	100
Multifak EP2 952	MIL-G-46006	99
Nebula EP-1	MIL-G-18709	84
PED-3005	MIL-G-3545B	75-76
PED-3350	MIL-G-21164	85-86
PED-3527	MIL-G-23827	89-90
Rockwell 950	MIL-G-6032	79-80
Royco 24R	MIL-G-10924	82
Royco 27	MIL-G-23827	89-90
Royco 32B	MIL-G-6032	79-80
Royco 37R	MIL-G-25537	93
Royco 43	MIL-G-4343	77-78
Royco 45A	MIL-G-3545	75-76
Royco 49	MIL-G-23549 (ASG)	87

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Royco 60R	MIL-G-25760 (ASG)	95-96
Royco 64	MIL-G-21164 (ASG)	85-86
Royco 87R	MIL-G-7187	81
Shell B&B Grease	MIL-G-10924	82
Shell Cyprina Grease 3	MIL-G-18709 (Navy)	84
Shell Darina Grease 2	MIL-G-18709 (Navy)	84
Southwest No. 3212	MIL-G-18709 (Navy)	84
Supermil Grease 72832	MIL-G-23827A	89-90
Supermil Grease No. 90781	MIL-G-18709	84
Supermil ASU Grease No. 31052	MIL-G-25013	91-92
Supermil ASU Grease No. 06752	MIL-G-25760 (ASG)	95-96
Templube No. 124	MIL-G-4343	77-78
TG-4727 Grease	MIL-G-21164 (ASG)	85-86
TG-4831 Grease	MIL-G-25537 (ASG)	93**
Unitemp EP	MIL-G-23827	89-90
Vac Kote 36209	None	34
Versilube G-350	MIL-G-15719	83

** Product conforms to specification but is not listed on page indicated.

HYDRAULIC FLUIDS

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII	Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Anderol L-826	None	67	Hydraulic Oil 3124	MIL-H-46004 (ORD)	125-126
Avrex 903	MIL-H-6083	121**	Oronite 70	None	131
Brayco 745	None	130	Oronite 6294	MIL-H-27601	123-124
Brayco 760	MIL-H-46004 (ORD)	125-126	Oronite 8200	None	131
Brayco Micronic 762	None	129	Oronite M2-V	None	131
Brayco 777	None	128	PED-3337, -3565	MIL-H-5606	119-120
Brayco 783A	MIL-H-6083	121**	Petrofluid 5606B	MIL-H-5606	119-120
Brayco 830	None	67-68	PQ Hydraulic Fluid 4226	MIL-H-5606	119-120
Brayco Micronic 756C	MIL-H-5606	119-120	PQ 1307	MIL-H-6083	121**
Brayco Micronic 756D	MIL-H-5606	119-120	Royco 745	None	130
Brayco Micronic 762	None	129	Royco 756A & B	MIL-H-5606	119-120
Brayco NPT-5	None	67-68	Royco 760	MIL-H-46004 (ORD)	125-126
Code 4646	MIL-H-46004 (ORD)	125-126	Royco 783B	MIL-H-6083	121
Code 4733	MIL-H-6083	121**	Royco 820X	None	127
Du Pont PR-143	None	59, 71	Royco Micronic 756B	MIL-H-5606	119-120
EF 100	MIL-H-46004 (ORD)	125-126	Royco Micronic 745	None	130
Freon E1, E2, E3, E4, E5	None	63	Shell XSL 7828	MIL-H-5606	119-120
			Stauffer 3664	None	67
Humble 3126 HVD Oil	MIL-H-5606	119-120	Union Carbide YT-283	MIL-H-5606	119-120
Humble 3160	MIL-H-27601	123-124	Univis PJ-44	MIL-H-6083	121
Hydraulic Oil AA	MIL-H-5606	119-120			

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** Product conforms to specification but is not listed on page indicated.

COMPOUNDS

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Braycote 202	MIL-C-11796	116
Braycote 236	VV-P-236	113
Braycote 655	MIL-T-5544	115
Cosmoline 1060	MIL-C-11796	116
DAG 217	MIL-T-5542	114
Dow Corning 4 Compound	MIL-S-8660	117-118
Esso Aviation Anti-Seize Compound 1	MIL-T-5544	115
Franklin H-2, H-10	MIL-C-11796	116
Humble 4024 Rust Preventive	MIL-C-11796	116
Insul-Grease G-624	MIL-S-8660	117-118
Kendex 7010	MIL-C-11796	116
Nox-Rust 507	MIL-C-11796	116
Parmo 70	VV-P-236	113
Petrotect P-50	MIL-C-11796	116
Rectorseal No. 15	MIL-T-5542	114
Royco IR	VV-P-236	113
Royco 44	MIL-T-5544	115
Tectyl 435	MIL-C-11796	116
Union Carbide Y2900	MIL-S-8660	117-118

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NONSPECIFICATION FLUIDS

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Anderol L-826	None	67-68
Apiezon Fluids	None	55
Brayco 707	None	58
Ball Brothers Vac Kote 36218, 36233, 36234	None	56
Brayco NPT 5, 830	None	67-68
Dow Corning FS-1281	None	105-106
Dow Corning Silicones	None	135
Du Pont PR-143	None	59
Freon E1, E2, E3, E4, E5	None	63
G. E. Silicone Fluids (Viscasil)	None	133-134
Royco No. 2	None	73
Stauffer 3664	None	67-68

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NONSPECIFICATION GREASES

Trade Name or Commercial Designation*	Specification No. If Qualified	Data Sheet Page No. Section BIII
Anderol L-758	None	102
Anderol L-762	None	103
Apiezon Greases	None	104
Braycote 617	None	101
Dow Corning FS-1281	None	105-106
Vac Kote 36209	None	109
Micronic 803	None	108
Halocarbon Synthetic Greases	None	107
Krytox Greases	None	111-112

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LUBRICATING OIL SPECIFICATIONS

		Page Numbers Section BII	Page Numbers Section BIII
VV-L-800	Lubricating Oil, General Purpose, Preservative/Water Displacing (Low Temperature)	1	1
VV-L-820	Lubricating Oil, General Purpose (light)	7	
VV-L-825	Lubricating Oil, Refrigerant Compressor	1	3
VV-L-1071	Lubricating Oil, Steam Cylinder, Mineral	2	4
MIL-L-2104	Lubricating Oil, Internal Combustion Engine (heavy duty)	2	5
MIL-L-2105	Lubricating Oil, Gear, Multipurpose	3	11
MIL-L-3150	Lubricating Oil, Preservative, Medium	3	
MIL-L-3572	Lubricant, Colloidal Graphite in Oil	3	
MIL-L-3918	Lubricating Oil, Instrument, Jewel Bearing, Nonspreading, Low Temperature	4	17
MIL-L-6081	Lubricating Oil, Jet Engine	4	18
MIL-L-6082	Lubricating Oil, Aircraft Reciprocating Engine (piston)	5	19
MIL-L-6085	Lubricating Oil, Instrument, Aircraft, Low Volatility	5	21
MIL-L-6086	Lubricating Oil, Gear Petroleum Base	6	23
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base	6	25
MIL-L-7870	Lubricating Oil, General Purpose, Low Temperature		27
MIL-L-9000	Lubricating Oil, Internal Combustion Engine, Diesel	7	29

LUBRICATING GREASES SPECIFICATIONS

		Page Numbers Section BII	Page Numbers Section BIII
VV-G-632A	Grease, Industrial, General Purpose	19	
MIL-G-3545	Grease, Aircraft, High Temperature	20	75
MIL-G-4343	Grease, Pneumatic System	20	77
MIL-G-6032	Grease, Plug Valve, Gasoline and Oil Resistant	21	79
MIL-G-7187	Grease, Graphite, Aircraft Lubricant	21	81
MIL-G-10924	Grease, Automotive and Artillery	21	82
MIL-G-14931	Grease, Silicone for Use with Ammunition	22	
MIL-L-15719	Lubricating Grease (high-temperature) Electric Motor, Ball and Roller Bearings	22	83
MIL-G-18709	Grease, Ball and Roller Bearings (Navy)	22	84
MIL-G-21164	Grease, Molybdenum Disulfide (for low and high temperatures)	23	85
MIL-G-22615	Grease, Lubricating, For Low and High Temperature	23	
MIL-G-23549	Grease, General Purpose	23	87
MIL-G-23827	Grease, Aircraft and Instrument, Gear and Actuator Screw	24	89
MIL-G-24139	Grease, Multipurpose, Quiet Service	24	
MIL-G-25013	Grease, Aircraft, Ball and Roller Bearing	25	91
MIL-G-25537	Grease, Aircraft, Helicopter Oscillating Bearing	25	93
MIL-G-25760	Grease, Aircraft, Ball and Roller Bearing, Wide Temperature Range	26	95

		Page Numbers	
		Section BII	Section BIII
MIL-G-27549	Grease, Aircraft, Heavy Load Carrying	26	94
MIL-G-27617	Grease, Aircraft, Fuel and Oil Resistant	26	97
MIL-G-38220	Grease, Aircraft High Speed, Ball and Roller Bearing	27	
MIL-G-38277	Grease, Aircraft, High Speed Ball and Roller Bearing, 316°C (600°F)	27	
MIL-G-46003	Grease, Rifle	28	
MIL-G-46006	Grease, Aircraft	28	99
MIL-G-81322	Grease, Aircraft, General Purpose Wide Temperature Range	28	100
MIL-G-83261	Grease, Aircraft, Extreme Pressure, Antiwear	29	

ANTISEIZE AND CORROSION COMPOUNDS SPECIFICATIONS

Specification	Title	Page Numbers Section BII	Page Numbers Section BIII
VV-P-236	Petrolatum, Technical	29	113
TT-A-580	Antiseize Compound, White Lead Base, General Purpose	29	
MIL-A-907	Antiseize Compound, High Temperature (Navy)	30	
MIL-T-5542	Thread Compound, Antiseize and Sealing, Oxygen	30	114
MIL-T-5544	Thread Compound, Antiseize, Graphite-Petroleum		115
MIL-C-5545	Corrosion Preventive, Aircraft Engine, Heavy Oil Type	30	
MIL-C-8188	Corrosion Preventive Oil, Gas Turbine Engine, Aircraft Synthetic Base	31	
MIL-S-8660	Silicone Compound	31	117
MIL-C-11796	Corrosion Preventive, Petrolatum, Hot Application	32	116
MIL-C-16173	Corrosion Preventive Compound, Solvent Cutback, Cold Application	32	

HYDRAULIC AND DAMPING FLUID SPECIFICATIONS

		Page Numbers	
		Section BII	Section BIII
VV-B-680	Brake Fluid, Automotive	33	
VV-D-001078	Damping Fluid, Silicone Base, Dimethyl Polysiloxane	33	
MIL-H-5606	Hydraulic Fluid, Petroleum, Base, Aircraft, Missile and Ordnance	34	119
MIL-H-6083	Hydraulic Fluid, Petroleum Base for Preservation and Testing	35	121
MIL-H-8446	Hydraulic Fluid, Nonpetroleum Base, Aircraft	35	
MIS-10137	Hydraulic Fluid, Petroleum Base, Intermediate Viscosity	36	
MIS-10150	Hydraulic Fluid, Petroleum Base, Low Temperature Corrosion Preventing	36	
MIL-H-13866	Hydraulic Fluid, Petroleum Base, Artillery Recoil, Special	37	
MIL-H-13910	Hydraulic Fluid, Polar Type Automotive Brake, All-Weather	37	
MIL-F-17111	Fluid, Power Transmission	37	
MIL-H-19457	Hydraulic Fluid, Fire Resistant	38	
MIL-H-27601	Hydraulic Fluid, Petroleum Base, High Temperature, Flight Vehicle	39	123
MIL-H-46001	Hydraulic Fluid, Petroleum Base, for Machine Tools	39	
MIL-H-46004	Hydraulic Fluid, Petroleum Base, Missile	40	125
MIL-S-46013	Silicone Fluid, Shock Absorber, Arctic	40	

LUBRICATING OILS

Spec. or Name / Properties and Uses	VV-L-800	VV-L-825	MIL-L-2104	MIL-L-2105	MIL-L-3918	MIL-L-6081	MIL-L-6082
Fluid Type	Petroleum	Petroleum	Petroleum	Petroleum	Synthetic	Petroleum	Petroleum
Fluid Properties							
Foam-Resistant		X	X	X			
Wear-Resistant (E.P.)			X	X			
Corrosion Inhibiting	X		X	X	X	X	X
Oxidation-Resistant		X	X	X	X	X	
Water-Resistant	X						
Detergent Containing			X				
Good Storage Stability	X	X	X	X			X
Usable Temperature Range							
Low, °C (°F)	-40 (-40)	-37 (-35)	-23 (-10)	-34 (-30)	-40 (-40)	-54 (-65)	-18 (0)
High, °C (°F)	93 (200)	218 (425)	82 (180)	82 (180)	121 (250)	107 (225)	177 (350)
Flash Point, °C (°F)	135 (275)	232 (450)	204 (400)	191 (375)	149 (300)	107 (225)	216 (420)
Compatibility with:							
Rubber	X	X	X	X		X	X
Jet Fuel							
Rocket Fuel, Liquid							
Rocket Fuel, Solid							
"LOX"							
Other Fluids							
Uses							
General Purpose	X		X	X			
Bearings:							
Low Speed	X					X	
High Speed						X	X
Journal	X		X	X	X	X	X
Sliding Surfaces	X		X	X		X	X
Ball			X	X		X	X
Roller			X	X		X	X
Instrument					X		
Sintered							
Gears:							
Planetary							
Spur				X			
Worm				X			
Heavy Duty				X			
Light Duty				X			
Compressors:							
Reciprocating		X					
Rotary		X					
Engines:							
Inter. Comb.			X				
Aircraft, Reciprocating							X
Aircraft, Jet						X	
Electrical Equipment							
High Speed Equipment			X	X		X	X
Low Speed Equipment	X		X	X		X	X
Fluid Couplings							
Torque Converters							
Heat Transfer							
NOTES:		Four oil types.	Three oil grades.	Three oil grades	For use with jewel bearings.	Can be used as hyd. oil.	Nonadditive oil two grades.

Spec. or Name / Properties and Uses	MIL-L-6085	MIL-L-6086	MIL-L-7808	MIL-L-7870	MIL-L-9000	MIL-L-9236	MIL-O-11773
Fluid Type	Synthetic1/	Petroleum	Synthetic1/	Petroleum	Petroleum	Synthetic1/	Synthetic
Fluid Properties							
Foam-Resistant		X	X		X	X	
Wear-Resistant (E.P.)		X	X		X	X	
Corrosion Inhibiting	X	X	X	X	X	X	X
Oxidation-Resistant	X	X	X	X	X	X	X
Water-Resistant		X		X			
Detergent Containing					X		
Good Storage Stability	X	X			X		
Usable Temperature Range							
Low, °C (°F)	-57 (-70)	-40 (-40)	-54 (-65)	-54 (-65)	-29 (-20)	-40 (-40)	-54 (-65)
High, °C (°F)	121 (250)	121 (250)	149 (300)	71 (160)	204 (400)	204 (400)	121 (250)
Flash Point, °C (°F)	185 (365)	154 (310)	204 (400)	129 (265)			
Compatibility with:							
Rubber	X-Syn.	X	X-Syn.	X	X	X-Syn.	
Jet Fuel							
Rocket Fuel, Liquid							
Rocket Fuel, Solid							
"LOX"							
Other Fluids							
Uses							
General Purpose	X			X			
Bearings:							
Low Speed	X	X	X	X	X	X	X
High Speed	X	X	X		X	X	
Journal		X	X	X	X	X	
Sliding Surfaces		X	X	X	X	X	X
Ball	X	X	X	X	X	X	
Roller	X	X	X	X	X	X	
Instrument	X			X			
Sintered				X			X
Gears:							
Planetary			X			X	
Spur		X					
Worm		X					
Heavy Duty						X	
Light Duty		X	X			X	
Compressors:							
Reciprocating							
Rotary							
Engines:							
Inter. Comb.					Diesel		
Aircraft, Reciprocating							
Aircraft, Jet			X			X	
Electrical Equipment			X				
High Speed Equipment	X		X			X	
Low Speed Equipment	X		X	X		X	X
Fluid Couplings							
Torque Converters							
Heat Transfer							
NOTES: 1/ Diester oil.	Squirt can type applications.	Reduction gear boxes two grades		Squirt can type applications see VV-L-800.			

LUBRICATING OILS

Spec. or Name / Properties and Uses	MIL-L-15016	MIL-L-15019[1/]	MIL-L-21260	MIL-L-22851	MIL-L-23699	MIL-L-25336	MIL-L-25681
Fluid Type	Petroleum	Petroleum	Petroleum	Petroleum	Synthetic[2/]	Synthetic[2/]	Silicone
Fluid Properties							
Foam-Resistant	X		X	X	X	X	
Wear-Resistant (E.P.)					X	X	X
Corrosion Inhibiting	X	X	X		X	X	
Oxidation-Resistant			X	X	X		
Water-Resistant		X					
Detergent Containing							
Good Storage Stability	X	X		X	X	X	X
Usable Temperature Range							
Low, °C (°F)	-23 (-10)	-23 (-10)	-29 (-20)	-18 (0)	-40 (-40)	-54 (-65)	-43 (-45)
High, °C (°F)	266 (510)	177 (350)	182 (360)	204 (400)	204 (400)	149 (300)	260 (500)
Flash Point, °C (°F)			182 (360)	216 (420)	232 (450)	204 (400)	274 (525)
Compatibility with:							
Rubber	X	X	X	X	X-Syn.	X	X
Jet Fuel							
Rocket Fuel, Liquid							
Rocket Fuel, Solid							
"LOX"							
Other Fluids							
Uses							
General Purpose	X	X					
Bearings:							
Low Speed	X	X	X	X	X	X	X
High Speed			X	X	X	X	
Journal			X	X	X	X	X
Sliding Surfaces	X	X	X	X	X	X	X
Ball	X	X	X	X	X	X	
Roller	X	X	X	X	X	X	
Instrument							
Sintered							
Gears:							
Planetary					X	X	
Spur						X	
Worm		X				X	
Heavy Duty					X	X	
Light Duty		X	X		X	X	
Compressors							
Reciprocating							
Rotary							
Engines:							
Inter. Comb.			X				
Aircraft, Reciprocating				X			
Aircraft, Jet					X	X	Sliding surfaces
Electrical Equipment							
High Speed Equipment	X	X	X	X	X	X	
Low Speed Equipment			X	X	X	X	X
Fluid Couplings							
Torque Converters							
Heat Transfer							
NOTES: 1/ Used in wick feed lubrication. 2/ Diester oil.		Contains a fatty acid additive.	Preservative type oil.	Ashless engine oil.	Improved diester syn.	High load gear box oil.	Contains MoS_2 additive.

Spec. or Name / Properties and Uses	MIL-L-26087	MIL-L-27694	MIL-L-45199	Wide Temperature Oils: Anderol L-826	Wide Temperature Oils: Brayco NPT 5 & 830	Wide Temperature Oils: Stauffer 3664	Wide Temperature Oils: Du Pont PR-143
Fluid Type	Petroleum	Synthetic	Syn. or Pet.	Synthetic	Synthetic	Synthetic	Synthetic
Fluid Properties							
Foam-Resistant	X		X	X	X	X	
Wear-Resistant (E.P.)			X	X		X	
Corrosion Inhibiting	X	X		X		X	
Oxidation-Resistant	X	X	X	X	X	X	X
Water-Resistant							
Detergent Containing							
Good Storage Stability	X	X	X	X			
Usable Temperature Range							
Low, °C (°F)	-18 (0)	-54 (-65)	-29 (-20)	-40 (-40)	-34 (-30)	-37 (-35)	-46 (-50)
High, °C (°F)	93 (200)	204 (400)	182 (360)	260 (500)	260 (500)	260 (500)	371 (700)
Flash Point, °C (°F)	188 (370)	260 (500)	182 (360)	260 (500)	260 (500)	260 (500)	732 (1350)
Compatibility with:							
Rubber	X	X-Syn.		X	X	X	X
Jet Fuel							
Rocket Fuel, Liquid							
Rocket Fuel, Solid							
"LOX"							
Other Fluids							
Uses:							
General Purpose		X					
Bearings:							
Low Speed	X	X	X	X	X		X
High Speed			X	X	X		X
Journal	X		X	X	X	X	X
Sliding Surfaces	X		X	X	X	X	X
Ball		X	X	X	X	X	X
Roller		X	X	X	X	X	X
Instrument		X		X			
Sintered							
Gears:							
Planetary			X	X	X	X	X
Spur			X	X	X	X	X
Worm			X				
Heavy Duty				X	X	X	
Light Duty			X	X	X	X	
Compressors:							
Reciprocating	X						
Rotary						X	
Engines:							
Inter. Comb.			Diesel				
Aircraft, Reciprocating							
Aircraft, Jet						X	X
Electrical Equipment							
High Speed Equipment			X	X		X	X
Low Speed Equipment	X		X	X	X	X	X
Fluid Couplings							
Torque Converters							
Heat Transfer							
NOTES:		Squirt can type oil.		Also used as hyd. fluid.	Ester base gear, box oil.	Polyester base turbine oil.	Hyd. fluid or turbine engine oil.

LUBRICATING OILS

Spec. or Name / Properties and Uses	Elec. Equipment Brayco 707	Elec. Equipment Brayco 810-13	Vac. Pump Oil Apiezon	Use in Vacuum Vac Kote	Use in Vacuum Apiezon	Liquid Oxygen Compatible Krytox 143	Liquid Oxygen Compatible Vac Kote 36218	Liquid Oxygen Compatible Halocarbon
Fluid Type	Petroleum	Synthetic	Synthetic	Synthetic	Synthetic	Synthetic	Synthetic	Fluorocarbon
Fluid Properties								
Foam-Resistant		X	X	X	X	X	X	X
Wear-Resistant (E.P.)		X		X			X	X
Corrosion Inhibiting	X		X	X			X	X
Oxidation-Resistant	X	X	X					X
Water-Resistant				X			X	
Detergent Containing	X							
Good Storage Stability		X	X	X	X	X	X	X
Usable Temperature Range								
Low, °C (°F)	-54 (-65)	-48 (-55)	-15 (5)	-48 (-55)	-1 (30)	-57 (-70)	-40 (-40)	-96 (-140)
High, °C (°F)	121 (250)	316 (600)	210 (410)	121 (250)	X	260 (500)	232 (450)	204 (400)
Flash Point, °C (°F)	135 (275)	None	246 (475)	288 (550)	310 (590)	None	260 (500)	None
Compatibility with:								
Rubber		X	X		X		X	X
Jet Fuel		X		X		X		
Rocket Fuel, Liquid		X				X		X
Rocket Fuel, Solid								
"LOX"						X	X	
Other Fluids	X	X		X	X	X		X
Uses:								
General Purpose								
Bearings:								
Low Speed	X	X		X	X	X	X	X
High Speed	X	X		X			X	
Journal		X		X	X	X	X	X
Sliding Surfaces	X	X	X	X	X	X	X	X
Ball				X			X	X
Roller				X	X	X	X	X
Instrument	X		X	X			X	X
Sintered								
Gears:								
Planetary		X		X			X	
Spur		X		X		X	X	X
Worm				X		X	X	X
Heavy Duty		X		X	X		X	X
Light Duty	X	X		X	X	X	X	X
Compressors:								
Reciprocating								X
Rotary								X
Engines:								
Inter. Comb.								
Aircraft, Reciprocating								
Aircraft, Jet								
Electrical Equipment	X	X		X			X	X
High Speed Equipment			X	X		X	X	
Low Speed Equipment	X	X	X	X		X	X	X
Fluid Couplings								X
Torque Converters								X
Heat Transfer		X						X
NOTES:			For sealed systems.	For vacuum and space.	Oil for gland seals, etc.	Not for Al or Mg parts.	For vacuum and space.	

Spec. or Name / Properties and Uses	Heavy Duty	Low Temperature		Low Volatility	Instrument Oils	
	Brayco 450	Halocarbon Fluids	Fomblin Y	Du Pont Freon	Kendall SRG	Royco No. 2
Fluid Type	Petroleum	Fluoro-carbon	Fluoro-carbon	Fluoro-carbon	Mineral	Synthetic
Fluid Properties						
Foam-Resistant		X	X			
Wear-Resistant (E.P.)	X	X	X		X	
Corrosion Inhibiting	X	X	X	X		
Oxidation-Resistant	X	X	X	X	X	X
Water-Resistant						
Detergent Containing						
Good Storage Stability	X	X	X		X	X
Usable Temperature Range						
Low, °C (°F)	-43 (-45)	-79 (-110)	-73 (-100)	-71 (-95)	-26 (-15)	-62 (-80)
High, °C (°F)	166 (330)	260 (500)	260 (500)	204 (400)	260 (500)	210 (410)
Flash Point, °C (°F)	166 (330)	None	None	None	288 (550)	191 (375)
Compatibility with:						
Rubber	X	X	X	X		
Jet Fuel						
Rocket Fuel, Liquid		X				
Rocket Fuel, Solid						
"LOX"		X	X			
Other Fluids			X			
Uses:						
General Purpose						
Bearings:						
Low Speed		X	X	X		
High Speed						
Journal	X	X	X	X		
Sliding Surfaces	X	X	X	X		
Ball	X	X	X	X	X	X
Roller	X	X	X	X	X	X
Instrument		X	X	X	X	X
Sintered						
Gears:						
Planetary	X					
Spur		X	X			
Worm		X	X			
Heavy Duty	X	X	X			
Light Duty	X	X	X	X	X	X
Compressors:						
Reciprocating		X	X			
Rotary		X	X			
Engines:						
Inter. Comb.						
Aircraft, Reciprocating						
Aircraft, Jet						
Electrical Equipment		X	X			
High Speed Equipment	X				X	X
Low Speed Equipment	X	X	X	X	X	X
Fluid Couplings	X	X	X			
Torque Converters	X	X	X			
Heat Transfer		X	X			
NOTES:	Low viscosity.	Good lub. not for Al or Mg parts.	Not for Al or Mg parts.	Includes many fluids.	Four grades of gyro oil.	

Spec. or Name Properties and Uses	MIL-G-3545	MIL-G-4343	MIL-G-6032	MIL-G-7187	MIL-G-10924	MIL-L-15719	MIL-G-18709
Lubricant Properties:							
Base Oil	Petroleum	Silicone	No Limit	Petroleum	Pet/Syn.	Silicone	Petroleum
Thickener	Nonsoap	X	X	Soap	X	Lith.-Soap	X
Dropping Point, °C (°F)	177 (350)	163 (325)	127 (260)	149 (300)		191 (375)	149 (300)
Usable Temp. Range							
Low, °C (°F)	-40 (-40)	-54 (-65)	-29 (-20)	-40 (-40)	-54 (-65)	-18 (0)	0 (32)
High, °C (°F)	149 (300)	93 (200)	149 (300)	71 (160)	79 (175)	149 (300)	107 (225)
Wear-Resistant (E.P.)				X			
Corrosion-Inhibiting	X	X	X		X	X	X
Oxidation-Resistant	X	X	X	X	X	X	
Water-Resistant	X	X	X	X	X	X	
Good Storage Stability	X	X	X	X	X	X	X
Compatibility with:							
Rubber & Neoprene	X	X	X	X			X
Paint & Lacquers	X	X	X	X			X
Plastics	X	X	X				X
Jet Fuel & Gasoline			X				
Solvents			X				
Acids							
Rocket Fuels, Liquid							
Rocket Fuels, Solids							
"LOX"							
Nitrogen Tetroxide							
Impact Compatibility							
"LOX" (AMBA)							
Nitrogen Tetroxide							
Uses:							
General Purpose	X		X		X		X
Electrical Equipment	X	X				X	X
Aircraft	X	X	X	X		X	
Instrument							
Ball or Roller Bearings	X					X	X
Low Speed	X					X	X
Medium Speed	X					X	X
High Speed	X					X	
Plain Bearings	X	X	X	X	X	No	
Sliding Surfaces	X	X	X	X	X	No	
Gears:							
Spur	X			X	X	No	X
Worm	X			X	X	No	X
Planetary	X					No	X
NOTES:	High speed, wide temperature range aircraft grease, bearing lubrication and rust protection.	Pneumatic system lubricant, rubber to metal.	Plug valve grease, resist fuels, water and some solvents. Low evaporation. Two types.	Graphite grease for heavy load, low speed equipment, infrequent lubrication. Not for ball bearings.	Corrosion resistant lubricant for sliding surfaces; automotive and artillery equipment	High temperature grease for ball and roller bearings.	General usage, medium speed ball and roller bearing lubricant.

LUBRICATING GREASES

Spec. or Name / Properties and Uses	MIL-G-21164	MIL-G-23549	MIL-G-23827	MIL-G-25013	MIL-G-25537	MIL-G-25760	MIL-G-27549
Lubricant Properties:							
Base Oil	Pet/Syn.	Petroleum	Synthetic		Petroleum	Pet/Syn.	
Thickener	X	Nonsoap	X		X	X	Nonsoap
Dropping Point, °C (°F)	163 (325)	232 (450)	163 (325)	232 (450)	138 (280)	260 (500)	232 (450)
Usable Temp. Range							
Low, °C (°F)	0 (32)	-18 (0)	-54 (-65)	-73 (-100)	-54 (-65)	-54 (-65)	-54 (-65)
High, °C (°F)	121 (250)	177 (350)	121 (250)	232 (450)	71 (160)	177 (350)	218 (425)
Wear-Resistant (E.P.)		X	X		X	X	X
Corrosion Inhibiting	X	X	X	X	X	X	X
Oxidation-Resistant	X	X	X	X	X	X	X
Wear-Resistant	X	X	X	X	X	X	X
Good Storage Stability	X	X	X	X	X	X	X
Compatibility with:							
Rubber & Neoprene		X			X		X
Paint & Lacquers		X			X		X
Plastics		X			X		X
Jet Fuel & Gasoline							
Solvents							
Acids							
Rocket Fuels, Liquid							
Rocket Fuels, Solids							
"LOX"							
Nitrogen Tetroxide							
Impact Compatibility (AMBA)							
"LOX"							
Nitrogen Tetroxide							
Uses:							
General Purpose	X	X	X		X	X	X
Electrical Equipment							
Aircraft	X	X	X	X	X	X	X
Instrument			X				
Ball or Roller Bearings	X	X		X	X	X	X
Low Speed	X	X		X	X	X	X
Medium Speed	X	X		X	X	X	X
High Speed				X		X	
Plain Bearings	X	X		X	X	X	X
Sliding Surfaces	X	X		X	X	X	X
Gears:							
Spur	X	X	X	X	X		X
Worm	X	X	X	X	X		X
Planetary				X	X		X
NOTES:	Shear-resistant wide temperature grease. Metal-to-metal antifriction bearings. Contains micro-MoS_2.	Contains MoS_2 high pressure, medium speed grease, for sliding surfaces and rust protection.	Antifriction bearing grease for low temperature and torque.	Aircraft ball and roller bearings. Extreme high and low temperature.	Bearing lubricant for oscillating motion. Helicopter gear, etc.	Wide temperature ball and roller bearing.	High load aircraft grease, wide temperature.

LUBRICATING GREASES

Spec. or Name / Properties and Uses	MIL-G-46006	MIL-G-81322	Nonspecification Greases: Braycote 617	Dow FS 1281	Apiezon Greases	Anderol L-758	Anderol L-762
Lubricant Properties:							
Base Oil	Petroleum	Pet/Syn.	Perfluoro-carbon	Fluoro-silicone	Synthetic	Silicone	Synthetic*
Thickener	X	X	TFE	Silica	Nonmelting	Nonmelting	Nonmelting
Dropping Point, °C (°F)	177 (350)	260 (500)		260 (500)		260 (500)	260 (500)
Usable Temp. Range							
Low, °C (°F)	0 (32)	-54 (-65)		-62 (-80)	-10 (14)	-29 (-20)	-40 (-40)
High, °C (°F)	135 (275)	177 (350)		204 (400)	240 (464)	343 (650)	260 (500)
Wear-Resistant (E.P.)	X	X	X	X		X*	X
Corrosion Inhibiting	X	X	X			X	X
Oxidation-Resistant	X	X	X	X	X	X	X
Water-Resistant	X	X	X	X	X	X	X
Good Storage Stability		X	X	X	X	X	X
Compatibility with:							
Rubber & Neoprene	X		X	X			
Paint & Lacquers	X		X	X			
Plastics	X		X	X			
Jet Fuel & Gasoline				X	X		
Solvents			X	X	X		
Acids			X	X	X		
Rocket Fuels, Liquid			X	X			
Rocket Fuels, Solids			X	X			
"LOX"			X	X			
Nitrogen Tetroxide			X	X			
Impact Compatibility (AMBA)							
"LOX"			X	X*			
Nitrogen Tetroxide			X				
Uses:							
General Purpose	X	X			X		X
Electrical Equipment					X		
Aircraft	X	X					
Instrument			X	X			
Ball or Roller Bearings	X	X			X		
Low Speed	X	X	X	X		X	X
Medium Speed	X	X			X		X
High Speed		X					
Plain Bearings	X	X	X	X	X	X	X
Sliding Surfaces	X	X	X	X	X	X	X
Gears:							
Spur	X	X					X
Worm	X	X					
Planetary	X	X					
NOTES:	General aircraft grease for extreme pressure and moisture protection.	Wide temperature general purpose grease. Antifriction bearings, gear boxes and plain bearings.	Manufactured in accordance with Formula PD-817, Frankford Arsenal.	* Significant insensitivity.	Vacuum and laboratory grease. High purity. Seven greases, wide range of properties.	* MoS_2 added to increase lubricity.	* Medium heavy diester. Good load-carrying ability.

LUBRICATING GREASES

Spec. or Name / Properties and Uses	Vac Kote 36209	Micronic 803	Krytox Greases	Halocarbon Greases	
Lubricant Properties:					
Base Oil	Synthetic	Synthetic	Synthetic	Synthetic	
Thickener	Nonmelt		Vydax	Sil. Gel/Wax	
Dropping Point, °C (°F)	204 (400)	253 (488)		149 (300)	
Usable Temperature Range					
Low, °C (°F)	-46 (-50)	-23 (-10)	-34 (-30)	-40 (-40)	
High, °C (°F)	121 (250)	260 (500)	288 (550)	260 (500)	
Wear-Resistant (E.P.)	X	X	X		
Corrosion Inhibiting	X				
Oxidation-Resistant	X	X	X	X	
Water-Resistant			X	X	
Good Storage Stability	X		X	X	
Compatibility with:					
Rubber & Neoprene				X	
Paint & Lacquers					
Plastics				X	
Jet Fuel & Gasoline		X	X		
Solvents		X	X	X	
Acids					
Rocket Fuels, Liquid		X	X		
Rocket Fuels, Solids					
"LOX		X	X		
Nitrogen Tetroxide					
Impact Compatibility (AMBA)		X	X		
"LOX		X	X		
Nitrogen Tetroxide		X			
Uses:					
General Purpose	X	X	X	X	
Electrical Equipment	X			X	
Aircraft			X		
Instrument	X		X	X	
Ball or Roller Bearings	X	X	X	X	
Low Speed	X	X	X	X	
Medium Speed	X	X	X	X	
High Speed					
Plain Bearings	X	X	X	X	
Sliding Surfaces	X	X	X	X	
Gears:					
Spur		X	X	X	
Worm		X	X	X	
Planetary			X	X	
NOTES:	For space and vacuum applications.	High vacuum grease with oxidizer. Fuel resistant.	Seven high temperature multi-purpose greases, missile and space usage.	Eleven synthetic greases, wide property range. Not for use in aluminum or magnesium parts.	

ANTISEIZE AND CORROSION PREVENTIVE COMPOUNDS

Spec. or Name / Properties and Uses	Antiseize Compounds					Corrosion Preventive Materials	
	TT-A-580	MIL-T-5542	MIL-T-5544	VV-P-236	MIL-S-8660	MIL-L-8188	MIL-C-11796
Lubricant Properties:							
Base Oil	Petroleum	1/	Petroleum	Petroleum	Silicone	Diester	Petroleum
Thickener	White Lead	1/	Graphite				
Dropping Point °C (°F)				38 (100)			135 (57)
Usable Temperature Range							
Low, °C (°F)	-40 (-40)	-54 (-65)	0 (32)	-18 (0)	-54 (-65)	-54 (-65)	
High, °C (°F)	177 (350)	71 (160)	538 (1000)	38 (100)	204 (400)	149 (300)	57 (135)
Wear-Resistant (E.P.)						X	
Corrosion Inhibiting	X	X	X	X	X	X	X
Oxidation-Resistant	X	X	X	X	X	X	X
Water-Resistant	X		X	X	X	X	X
Good Storage Stability	X			X	X	X	X
Compatibility with:							
Rubber & Neoprene	X			X	X	X-Syn.	X
Paint & Lacquers	X			X	X	X	X
Plastics	X			X	X	X	X
Jet Fuel & Gasoline							
Solvents					X		
Acids							
Rocket Fuels, Liquid							
Rocket Fuels, Solids							
"LOX"	No	No	No				
Nitrogen Tetroxide							
Impact Compatibility							
"LOX" (AMBA)							
Nitrogen Tetroxide							
Uses:							
General Purpose Lubricant				X	X	X	
Electrical Equipment			No	X	X		
Aircraft				X	X	X	
Instrument				X	X	X	
Ball or Roller Bearings				X	X	X	
Low Speed				X	X	X	
Medium Speed						X	
High Speed						X	
Plain Bearings				X	X	X	
Sliding Surfaces				X	X	X	
Gears:							
Spur				X	X	X	
Worm				X	X	X	
Planetary				X		X	
NOTES: 1/ Not specified - contains no material inflammable with oxygen at 2,000 psi (mineral, vegetable or animal oils).	Antiseize compound for threaded fitting, steam, water and oil system to 150 psi.	Antiseize and seal compound for low-high pressure breathing oxygen to 2,000 psi.	Graphite antiseize high-temperature compound for spark plugs, etc.	Light duty, homogeneous material not for heavy loads or high temperature. Intended as preservative from moisture and corrosion.	For seals and electrical equipment, resist corrosion and moisture.	Oil-type corrosion preventive. Short life lubricant (25 hr.). Costly.	Hot application corrosion preventive for ferrous or nonferrous metals. Dip or brush application.

HYDRAULIC AND SILICONE FLUIDS

Spec. or Name Properties and Uses	Hydraulic Fluids					Silicone Fluids	
	MIL-H- 5606	MIL-H- 6083	MIL-H- 27601	MIL-H- 46004	MIL-H- 81019	VV-D- 001078 (GSA-FSS)	MIL-S- 81087
Fluid Type	Petroleum	Petroleum	Pet/Syn. Hyd.	Petroleum	Petroleum	Silicone	Silicone
Fluid Properties							
Foam-Resistant	X	X	X	X	X		
Wear-Resistant (E.P.)	X	X	X	X	X		
Corrosion Inhibiting	X	X	X	X	X		
Oxidation-Resistant			X	X	X		
Water-Resistant						X	
Detergent Containing							
Good Storage Stability	X	X	X	X	X		
Usable Temperature Range							
Low, °C (°F)	-54 (-65)	-54 (-65)	-40 (-40)	-59 (-75)	-68 (-90)		-73(-100)
High, °C (°F)	135 (275*)	93 (200)	316 (600*)	93 (200)	99 (210)		260(500)
Flash Point, °C (°F)	93 (200)	93 (200)	182 (360)	93 (200)	93 (200)		
Compatibility with:							
Rubber	X	X	X	X	X		
Jet Fuel							
Rocket Fuel, Liquid							
Rocket Fuel, Solid							
"LOX"							
Other Fluids							
Uses:							
General Purpose							
Bearings:							
Low Speed	X	X	X	X	X		X
High Speed							
Journal	X	X	X	X	X		X
Sliding Surfaces	X	X	X	X	X		
Ball	X	X	X	X	X		X
Roller							
Instrument							X
Sintered							X
Gears:							
Planetary							X
Spur							X
Worm							X
Heavy Duty							
Light Duty							X
Compressors:							
Reciprocating							
Rotary							
Engines:							
Inter. Comb.							
Aircraft, Reciprocating							
Aircraft, Jet							
Electrical Equipment						X	X
High Speed Equipment							
Low Speed Equipment	X	X	X	X	X		X
Fluid Couplings	X	X	X	X	X		X
Torque Converters	X	X	X	X	X		X
Heat Transfer				X	X	X	X
NOTES:	* Closed system.	Preservative type hyd. fluid.	* Closed system.	Low temp. hydraulic fluid.	Ultra-low temp. hyd. fluid.	See Sec. II, Item 4.1.2.	See Sec. II, Item 4.1.18.

HYDRAULIC AND SILICONE FLUIDS

Spec. or Name / Properties and Uses	Silicone Fluids		Hydraulic Fluids				
	General Electric	Dow Corning	Oronite M 2-V	Oronite 70	Oronite 8200	Royco 745	Royco 820
Fluid Type	Many	Many	Silicate Ester	Silicate Ester	Silicate Ester	Petroleum	Synthetic
	fluids	fluids					
Fluid Properties	having	having					
Foam-Resistant	wide	wide	X	X	X	X	X
Wear-Resistant (E.P.)	range	range	X	X	X	X	X
Corrosion Inhibiting	of	of				X	X
Oxidation-Resistant	prop-	prop-	X	X	X	X	X
Water-Resistant	erties.	erties.				X	
Detergent Containing							
Good Storage Stability			X		X	X	X
Usable Temperature Range							
Low, °C (°F)			-54 (-65)	-54 (-65)	-54 (-65)	-40 (-40)	-73 (-100)
High, °C (°F)			260 (500)	332 (630)	204 (400)	X	177 (350)
Flash Point, °C (°F)			216 (420)	221 (430)	199 (390)	149 (300)	216 (420)
Compatibility with:							
Rubber			WRT-Elastomers		WRT-Elastomers	X	Limited
Jet Fuel							
Rocket Fuel, Liquid							
Rocket Fuel, Solid							
"LOX"							
Other Fluids						X	X
Uses:							
General Purpose							
Bearings:							
Low Speed			X	X	X	X	X
High Speed			X	X	X	X	X
Journal			X	X	X		
Sliding Surfaces			X	X	X	X	X
Ball							
Roller							
Instrument							
Sintered							
Gears:							
Planetary							
Spur							
Worm							
Heavy Duty							
Light Duty							
Compressors:							
Reciprocating			X	X	X	X	X
Rotary			X	X	X	X	X
Engines:							
Inter. Comb.							
Aircraft, Reciprocating						X	X
Aircraft, Jet						X	X
Electrical Equipment							
High Speed Equipment						X	X
Low Speed Equipment						X	X
Fluid Couplings			X	X	X	X	X
Torque Converters			X	X	X		
Heat Transfer			X	X	X	X	X
NOTES:	See Section III.	See Section III.	Nontoxic, shear and thermal stable. Aircraft systems.	High temp. aircraft hydraulic systems.	Aircraft hydraulic systems. Nontoxic, thermal and shear stable.	Same as Brayco 745, for missiles.	For missile systems.

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BII - LUBRICANT MATERIALS - GENERAL DESCRIPTION

This section contains a listing of all lubricant materials that have been selected for inclusion in the handbook. In addition, there are several other material listings that do not appear on data sheets in Section IV. It is felt that certain of these may be of interest, but specific data could not be obtained on them.

The lubricants included have been subdivided into two main classes; those conforming to military specifications and nonspecification materials. Again, the two main classes have been subdivided into the general classes of oils, greases, hydraulic fluids and compounds.

The remainder of this section contains an ascending numerical listing of lubricants by classes, along with general descriptions of their chemical nature, limitations and use areas.

1.0 DESCRIPTION OF SPECIFICATION LUBRICANT MATERIALS

1.1 Lubricating Oils

1.1.1 VV-L-800A: Lubricating Oil, General Purpose, Preservative (Water-Displacing, Low Temperature) (Military Symbol PL-S, NATO Code: 0-190)

General characteristics: General purpose lubricating oil for protection of parts from corrosion and low temperature applications. Composition of oil is a petroleum fraction and additives, as required to meet specifications. This oil is used in many applications in place of MIL-L-7870.

Uses: General purpose preservative oil, intended for lubrication and protection against corrosion of small arms, automatic weapons, freeze mechanisms, squirt-can aircraft applications and whenever a general purpose, water-displacing, low temperature lubricating oil is required. Recommended usable temperature range, -40°C to 129°C (-40°F to 200°F). Usage below -40°C (-40°F) requires test application before adoption.

Limitations: Should not be used on aircraft equipment such as guns where operations at -54°C (-65°F) is necessary. Do not use this oil in food-processing or food-handling equipment which may contact food. Do not store gas-pressurized can of this oil at temperatures above 84°C (120°F).

1.1.2 VV-L-825a(2): Lubricating Oil, Refrigerant Compressor (NATO Code: None)

General characteristics: Refrigerant compressor lubricating oils consisting of well-refined petroleum oil base with additives to provide antifoam, pour point depressant, antioxidant, and viscosity improvers permitted. Available in four types.

Uses: For lubricating of compressor units in refrigeration equipment:

Type I (NATO Code 0-282) - reciprocating-type compressor (sulfur dioxide).
Type II (NATO Code 0-283) - reciprocating-type compressor (using Freon 12, methyl chloride, or ammonia).
Type III (NATO Code 0-284) - two-stage rotary type compressors.
Type IV (no NATO Code) - for use with Freon 22 type refrigerants.

Limitations: Usable temperature range:

Type I: -37°C to +149°C (-35°F to 300°F).
Type II: -36°C to +163°C (-32°F to +325°F).
Type III: -18°C to +218°C (0°F to +425°F).
Type IV: -37°C to +149°C (-35°F to +300°F).

1.1.3 VV-L-1071: Lubricating Oil, Steam Cylinder, Mineral (NATO Code: None)

General characteristics: This specification covers one type and two grades of mineral oil suitable for lubricating steam cylinders. Material shall contain no additives other than pour point depressants.

Uses: Military symbol 5190 (NATO Code 0-258) lubricating oil intended for use in saturated and superheated steam systems.

Military symbol 5230 (no NATO symbol) lubricating oil is essential to the lubrication of uniflow steam engine cylinders.

Limitations: Minimum pour point of both oils is 16°C (60°F). This specification encompasses the scope and incorporates the requirements of VV-0-611 and MIL-L-15018B. Military symbol 5190 oil replaces military symbol 5150 oil included in MIL-L-15018B.

1.1.4 MIL-L-2104B(d): Lubricating Oil, Internal Combustion Engine (Heavy Duty) (NATO Code: None)

General characteristics: This specification covers one type and three viscosity grades (10, 30, and 50) of heavy-duty engine oil consisting of a petroleum base compounded with functional additive materials (detergents, dispersants, oxidation, and corrosion inhibitors, etc.) necessary to meet specification requirements. It shall not contain any re-refined components.

Uses: This liquid is for crankcase lubrication of reciprocating internal combustion engines of both spark-ignition and combustion-ignition types used in ground equipment of all types and under all conditions of service when ambient temperatures are above -23°C (-10°F).

Limitations: This liquid is not recommended for gear box applications without prior performance evaluation. For highly supercharged compression-ignition engines operating at output levels of 1.034×10^6 N/m^2 (150 psi) brake mean effective pressure or above, it may be necessary to decrease oil drain periods or change to oils supplied under MIL-L-45199A and specifically intended for this service. This liquid shall be compatible with other oils qualified to this specification and shall have good storage life when stored in closed containers at normal temperatures.

1.1.5 MIL-L-2105B: Lubricating Oil, Gear, Multipurpose (NATO Code: None)

General characteristics: This specification covers one type and three viscosity grades (80, 90 and 140) of a multipurpose lubricating oil consisting of a petroleum or synthetically prepared base fluid and additives necessary to meet specification requirements. It has good moisture corrosion, load-carrying and extreme pressure characteristics as well as satisfactory thermal-oxidation stability. Operating temperature range is not specified, but is not recommended for extremely low temperatures below -34°C (-30°F).

Uses: Gear lubricant intended for automatic gear units, heavy-duty industrial type inclosed gear units, steering gears and fluid lubricated universal joints of automotive equipment (conditions of high speed and shock loading).

Limitations: These oils must not contain any re-refined components.

1.1.6 MIL-L-3150B: Lubricating Oil, Preservative, Medium (Military Symbol PL-M (NATO Code: 0-192)

General characteristics: Preservative lubricating oil consisting of a petroleum fraction containing additives necessary to meet specification requirements.

Uses: Intended for lubrication and protection against corrosion of ferrous and nonferrous metals, interior of gear assemblies, transmissions, differentials, etc. Not intended for the protection of internal combustion engines.

Limitations: This lubricating oil should not be used in food-processsing or food-handling machinery on surfaces that may contact food. Storage temperature range -40°C to +54°C (-40°F to +130°F).

1.1.7 MIL-L-3572(1): Lubricant, Colloidal Graphite in Oil (NATO Code: None)

General characteristics: This specification covers three grades (A - light, B - medium, and C - heavy) of lubricant consisting of stabilized colloidal electric furnace graphite dispersed in refined mineral lubricating oils. Operating temperature ranges are not specified.

Uses: Grade A oil is suitable for machine gun housing guides, windshield wipers, and other lightly loaded, sliding members exposed to weather. Grade B oil is suitable for gear trains of hot running torpedoes. Grade C oil is suitable for the lubrication of medium or heavy-duty gun slides without causing excessive resistance to counter-recoil at ambient temperatures down to -23°C (-10°F). It should retain sufficient lubricanting properties to permit free recoil and counter-recoil when the gun is heated as a result of sustained fire.

Limitations: It is not recommended for use in electrical equipment or for extremes of temperature.

1.1.8 MIL-L-3918: Lubricating Oil, Instrument, Jewel Bearing, Nonspreading, Low Temperature (NATO Code: None)

General characteristics: A nonpetroleum, special purpose lubricant consisting of a mixture of approximately 60% benzyl phenylundicarbonate, 40% diethylene glycol di-n-caproate with small amounts of dodecylpiperidine sterate (for oiliness) and p-test-butyl catechol (antioxidant). Although usable temperature range is not specified, this oil has good lubricating qualities at low to moderate temperatures.

Uses: This oil is intended for lubrication of steel pivot and jewel bearing combinations in timepieces and other fine instruments. It will allow operation of most instrument mechanisms at temperatures as low as -40°C (-40°F).

Limitations: This oil should not be used on instrument-type ball bearings because of the nonspreading properties of the material. Also not recommended for use at high temperatures above 121°C (250°F); nor on rough metal surfaces or in an environment containing dust or other foreign material that would reduce its nonspreading qualities.

1.1.9 MIL-L-6081C(2): Lubricating Oil, Jet Engine

Oil Grade	NATO Code
1005	0-132
1010	0-133

General characteristics: This specification covers two grades of jet engine lubricating oil consisting of a refined petroleum base and may contain oxidation inhibitors and pour point depressant to meet specification requirements. Operating temperature range is not specified but is usable as low as -40°C (-40°F) and -54°C (-65°F) depending on the grade of oil.

Uses: This oil is intended for lubrication of specific models of aircraft turbine engines.

Limitations: This oil shall not be used in aircraft turbine engines for which other lubricants are specified. Oil shall not contain any viscosity index improver.

1.1.10 MIL-L-6082D: Lubricating Oil, Aircraft Reciprocating Engine (Piston) (Grade 1068, NATO Code 0-113, and Grade 1100, NATO Code 0-117)

General characteristics: Specification covers two grades of refined petroleum product that may contain a pour point, but no other additive.

Uses: Intended for use in an aircraft reciprocating engine and for blending type IIa and type IIIa oils under MIL-L-22851.

Limitations: Temperature range: Grade 1065, -18°C to +149°C (0°F to 300°F); Grade 1100, -12°C to +177°C (10°F to 350°F).

1.1.11 MIL-L-6085A(2): Lubricating Oil, Instrument, Aircraft, Low Volatility (NATO Code: 0-147)

General characteristics: This oil is a low volatility, non-petroleum base lubricating oil with wide temperature, corrosion and oxidation properties. Composition consists of a synthetic base oil (carboxylic acid ester) with additives to impart oxidation stability and corrosion protection properties. It contains no pour point depressants or VI improvers. The operating temperature range is not specified but has a pour point of -57°C (-70°F) and a flash point of 185°C (365°F).

Uses: Intended for use in aircraft instruments, electronic equipment, or where a low evaporation oil is required for both high and low temperatures, and where oxidation and corrosion resistances are desired.

Limitations: The finished fluid must contain no resins, gums, rubber, fatty oils, oxidized hydrocarbons or other additives not approved by the qualifying agency. Containers for the fluid must have a warning note that this fluid may soften paint, natural rubber or neoprene and electrical insulating materials.

1.1.12 MIL-L-6086B(1): Lubricating Oil, Gear, Petroleum Base

Oil Grade	NATO Code
L (light)	0-153
M (medium)	0-155

General characteristics: This specification covers two grades of gear oil consisting of a well-refined mineral oil containing a suitable load-carrying additive. Operating temperature ranges are not specified but these oils have a pour point of -40°C to -29°C (-40°F to -20°F) and a flash point of +138°C to +154°C (+280°F to +310°F) depending upon the grades of oil.

Uses: Intended for the lubrication of aircraft gears at low temperature. Grade L oil is for extreme low temperatures. Grade M is for general use in aircraft gear mechanisms.

Limitations: This oil contains extreme pressure additives and is not suitable for lubrication of internal combustion engines. The EP additives in this oil shall not be corrosive, or cause excessive foaming and must not precipitate upon diluting the oil with additional mineral oil base stock.

1.1.13 MIL-L-7808G: Lubricating Oil, Aircraft Turbine Engine, Synthetic Base (NATO Code: 0-148)

General characteristics: This oil is a nonpetroleum base lubricating oil for aircraft turbine engines and similar equipment. It has good storage, wide temperature and environment limits. This oil shall be a synthetic base fluid (carboxylic acid ester), but additives to impart oxidation stability, corrosion-preventive properties, and antiwear properties are permitted.

The operating temperature range is not specified, but the nominal operating temperature range is -54°C to 149°C (-65°F to 300°F).

Uses: This oil is intended as a lubricating oil in specific models of aircraft turbine engines, helicopter transmissions and similar equipment.

Limitations: This oil should not be mixed with any oils other than MIL-L-7808 oils and revisions thereto. If the oil contains tricresyl phosphate additive, the supplier must certify that it contains less than 1.0% of the ortho isomer. It should not be used in systems designed solely for petroleum lubricants, as serious deterioration of rubber parts coatings and other organic materials may result.

1.1.14 VV-L-820B(1): Lubricating Oil, General Purpose (light) (NATO Code: None)

General characteristics: This specification covers a refined, low-viscosity petroleum product free from any extraneous material and objectionable odor. Usable temperature range is not specified but should be restricted to moderate temperatures.

Uses: Intended for lubrication of miscellaneous equipment requiring a light lubricating oil, such as typewriters, sewing machines, etc.

Limitations: Not recommended for extreme temperature ranges, low or high, nor for high loads.

1.1.15 MIL-L-9000G (Ships): Lubricating Oil, Shipboard Internal Combustion Engine, High Output Diesel (Military Symbol 9250, NATO Code: 0-274)

General characteristics: Homogeneous blend of petroleum base lubricating oil stock and additives, as necessary, to meet the specification requirements as a lubricant for high-output marine diesel engine and parts. When contaminated with sea water, this oil must still provide lubrication within specified limits.

Uses: Intended for use in advanced design high-output shipboard main propulsion and auxiliary diesel engines using fuel conforming to MIL-F-16884.

Limitations: Recommended temperature range, -12°C to +190°C (+10°F to 390°F). This oil is not suitable for crankcase use of gasoline engines. Future procurement of oils formerly covered by military symbol oils 9110 and 9500 of MIL-L-9000F should use applicable grades of MIL-L-2104. Requirement for military symbol 9170 of MIL-L-9000F is not included because of limited usage.

1.1.16 MIL-L-9236B(1): Lubricating Oil, Aircraft Turbine Engine, 204°C (400°F) (NATO Code: None)

General characteristics: This specification covers one grade of aircraft turbine lubricating oil of unrestricted composition. Additives for oxidation stability, corrosion preventive properties and antiwear properties are permitted. Operating temperature range is not specified but nominal range is for high temperatures up to +204°C (+400°F).

Uses: This oil is intended for use in specific models of aircraft turbine engines.

Limitations: This oil shall be miscible with other oils approved under this specification and under specifications MIL-L-7808 and MIL-L-25336. Mixtures shall not be turbid nor separate.

1.1.17 MIL-L-10295B: Lubricating Oil, Internal-Combustion, Sub-Zero

General characteristics: A low temperature lubricating oil consisting of a petroleum or combination thereof, with suitable additions to meet specification requirements.

Uses: Engine lubricating oil suitable for the crankcase of reciprocating spark-ignition and compression-ignited engines used in ground equipment for all types of services, when ambient temperatures are sub-zero range of -54°C to -18°C (-65°F to 0°F).

Limitations: This oil shall not contain any re-refined products.

1.1.18 MIL-L-10324A: Lubricating Oil, Gear, Sub-Zero (NATO Code: None)

General characteristics: A sub-zero gear lubricating oil consisting of a petroleum or synthetic base, or combinations thereof, containing suitable additive materials to meet specification requirements. This oil shall contain one of the approved EP additives used in a qualified Grade 90, gear lubricant, MIL-L-2105. The concentration of this EP additive in this gear oil shall be 50% greater than in Grade 90, MIL-L-2105 universal gear lubricant.

Uses: Suitable for the lubrication of automotive gear units, heavy-duty industrial-type enclosed gear units (including hypoid glass), steering gears, and fluid-lubricated universal joints of automotive equipment operating in ambient temperatures ranging from -18°C to -54°C (0°F to -65°F).

Limitations: Containers for this oil must be marked with a warning notice: POISON, AVOID SKIN CONTACT.

1.1.19 MIL-L-11734C: Lubricating Oil, Synthetic (for Mechanical Time Fuzes)

General characteristics: Specially formulated synthetic lubricating oil composition of which is specified both as to constituents employed and the percentages of each. (Di-(2-ethylhexel) sebacate, di(2-ethylhexyl)-azelate, phenyl-alpha-naphthylamine, and barium petroleum sulfonate).

Uses: Synthetic lubricating oil intended for use in mechanical time fuzes at ambient temperatures from -54°C to +52°C (-65°F to +125°F).

Limitations: Do not use in food-processing or food-handling machinery or surfaces that may contact food.

1.1.20 MIL-O-11773: Oil, Lubricating, Synthetic (for Impregnating Powder Metal Sleeve Bearings) (NATO Code:)

General characteristics: A special purpose synthetic lubricating oil of a specified composition consisting of purified di-(2-ethylhexyl)-sebacate to which is added 0.5%, by weight, of phenyl-alpha-naphthylamine.

Uses: A synthetic lubricating oil suitable for impregnating powder metal sleeve bearings at normal and below-freezing temperatures.

Limitation: Not satisfactory for high temperature applications.

1.1.21 MIL-L-14107B: Lubricating Oil, Low Temperature, Weapons (NATO Code: None)

General characteristics: This specification covers a low temperature preservative lubricating oil consisting of tetra-alkyl silicates with additive materials to inhibit rust and oxidation. Operating temperature range is not specified but this oil has a pour point of -59°C (-75°F) and a flash point of +164°C (+325°F).

Uses: Primarily intended for the lubrication of aircraft and ground weapons to insure efficient firing at low temperatures.

Limitations: This fluid may soften paint, natural rubber, plastic or neoprene with which it comes in contact. May be stored at temperatures ranging from -57°C (-70°F) to +49°C (+120°F).

1.1.22 MIL-L-15016B(1): Lubricating Oil, General Purpose (NATO Code: None)

General characteristics: This specification covers four grades of general purpose lubricating oil consisting of refined petroleum hydrocarbons free from additives except pour point depressant.

Uses: Military symbol oils 2110, 2135, 2190, and 3050 are suitable for all applications which require other than special lubricants; where temperature, load and corrosion requirements are not severe. Ground use only.

Limitations: Recommended temperature range:

Military Symbol Oil	Temperatures
2110	-18°C to +163°C (0°F to 325°F)
2135	-18°C to 171°C (0°F to 340°F)
2190	2°C to 177°C (35°F to 350°F)
3050	-18°C to 199°C (0°F to 390°F)

1.1.23 MIL-L-15019C: Lubricating Oil, Compounded

Military Symbol	NATO Code
4065	0-254
6135	None
7105	None
8190	None

General characteristics: This specification covers several grades of a compounded lubricating oil containing various fatty oils in various percentages. Because of multiple grades of oil available, this lubricant can be used over a wide temperature range, but is generally for elevated temperatures; nominal range is -12°C to +246°C (+10°F to +475°F).

Uses: Intended for special applications involving moisture or worm gears or wick feeds.

Limitations: For ground use only.

1.1.24 MIL-L-17331D (Ships): Lubricating Oil, Steam Turbine (Noncorrosive) (NATO Code: 0-250, Military Symbol: 2190-TEP)

General characteristics: This liquid is a petroleum base steam turbine lubricating oil which may or may not contain additives. The liquid is noncorrosive and has a work factor of 0.9 min. and is a homogeneous blend of virgin petroleum lubricating oil plus required additives to meet requirements of the specification. The operating temperature range is not specified, but general usage is between -7°C and 88°C (+20°F and 190°F) with short duration elevated temperature use to 121°C (250°F).

Uses: This liquid is a steam turbine lubricating oil for main turbines and gears, auxiliary turbine installations, certain hydraulic equipment, general mechanical lubrication, and air compressors.

Limitations: The liquid has limited use as hydraulic fluid and is not for low temperatures (minimum recommended temperature is -7°C (+20°F)). It is compatible with reference oils furnished by the government and other oils to this specification. Additives if used shall contain no chlorine or chlorinated materials.

1.1.25 MIL-L-17672B(2): Lubricating Oil, Hydraulic and Light Turbine, Noncorrosive

Military Symbol	NATO Code	Viscosity Grades, 99°C (210°F) 10^{-6} m^2/sec (centistokes)
2075 T-H	None	4.3 - 5.3
2110 T-H	None	5.3 - 6.7
2135 T-H	None	6.7 - 7.7

General characteristics: This specification covers one type and three grades of virgin petroleum base oil plus anticorrosion and antioxidation additive agents to meet specification requirements. Operating temperature range is not specified but generally from -18°C to +121°C (0°F to +250°F).

Uses: This fluid is intended for use in steam turbines, hydraulic systems, water turbines, water-wheel type generators, hydraulic-turbine governors, and in other applications where a high-grade lubricating oil having anticorrosion and antioxidation properties is required.

Limitations: There are no storage life requirements, but the liquid has good storage properties if stored in closed containers at normal temperatures. It shall be compatible with other reference oils furnished by the government. Compatibility is determined by mixing equal portions of specification oil and reference oil and passing requirements of this specification.

1.1.26 MIL-L-18486A(WP)(1): Lubricating Oil, Worm Gear (NATO Code: None)

General characteristics: High quality lubricating oil consisting of essentially a mixture of highly refined mineral oil and load-carrying additive.

Uses: Intended for heavy-duty, moderate extreme pressure use in enclosed housings employing a splash lubrication system containing worm gears, spur gears, or other power and motion transmission gears.

Limitations: Intended for applications at temperatures from -18°C (0°F) to +66°C (+150°F).

1.1.27 MIL-L-19701A(AS): Lubricant, All-Weather, Semi-Fluid for Aircraft Ordnances

General characteristics: Special purpose synthetic, low temperature, lubricants containing silicone components. Must be compatible with oil-resistant rubber covered by MIL-P-5516.

Uses: Intended for use on the entire assembly of aircraft machine guns, associated mechanisms, and other weapons at low temperatures, and under icing conditions. Also under cold sweat-cold cycling conditions. Temperature range -54°C (-65°F) to +71°C (160°F).

Limitations: Silicone component may irritate the eyes of personnel.

1.1.28 MIL-L-21260A: Lubricating Oil, Internal Combustion Engine, Preservative

Product Symbol	NATO Code
PE-1 (light)	C-640
PE-2 (medium)	C-642
PE-3 (heavy)	C-644

General characteristics: This specification covers three viscosity grade preservative lubricating oils used as lubricants in spark-ignition and compression-ignition types of reciprocating internal combustion engines. The finished oil may be a petroleum base of a synthetically prepared product, or a combination thereof, with or without additives. However, no re-refined components are permitted. The operating temperature ranges are not specified.

Uses: The oil is a crankcase oil for diesel or spark-ignition type internal combustion engines. Although intended principally as a static preservative, this oil may be used as an operating lubricant for short periods, and for some hydraulic equipment. It is compatible with other fluids to this specification and MIL-L-2104.

Limitations: This oil is not for low temperature usage and not generally for gear box applications.

1.1.29 MIL-L-22851B: Lubricating Oil, Aircraft Piston Engine (Ashless Dispersant) (NATO Code: None)

General characteristics: This specification covers one type of additive concentrate and two types of lubricating oil blended of lubricating oil and additives to impart oxidation stability and dispersant properties to aircraft engine oils qualified under MIL-L-6082, Grade 1100 and Grade 1065. Type I (no NATO code), additive concentrate; Type II (NATO Code 0-128), lubricating oil blend; Type III (NATO Code 0-123), lubricating oil blend.

Uses: These lubricating oils are intended for use in aircraft piston engines and must give a minimum of 1,000 hr. satisfactory service.

Limitations: Type II is for engines having a normal rating of 1,000 hp or greater. Type III is for engines having a normal rating of 1,000 or lower.

1.1.30 MIL-L-23699B(1): Lubricating Oil, Aircraft Turbine Engine, Synthetic Base (NATO Code 0-156)

General characteristics: One grade of aircraft gas turbine engine lubricating oil that is not limited in composition, except that it must not contain any organic compounds of titanium. Similar to MIL-L-7808 but has a higher viscosity and pour point.

Uses: Intended for use in specific models of aircraft gas turbine engines, helicopter transmissions and other aircraft machine gear boxes in the temperature range -40°C to +200°C (-40°F to +400°F). May be used where MIL-L-7808 has previously been used.

Limitations: Not suitable below -40°C (-40°F). Tricresyl phosphate additives, if present, shall not be more than 1% of the ortho isomer.

1.1.31 MIL-L-25336-B: Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, High Film Strength (NATO Code: None)

General characteristics: This specification covers one type of high film strength, synthetic base, lubricating oil that is not limited in composition. Additives to impart oxidation stability, corrosion-preventive properties, and antiwear properties are permitted. Operating temperature range is not specified but the pour point is -59°C (-75°F) and the flash point is +204°C (+400°F).

Uses: Intended for use in specified models of aircraft turbine engines and helicopter transmissions.

Limitations: Not interchangeable with, and not to be mixed with, any other aircraft engine oil. Should be used only where specified.

1.1.32 MIL-F-25598 (USAF): Oil, Hydraulic Missile, Petroleum Base (NATO Code: None)

General characteristics: This specification covers a low viscosity petroleum base hydraulic oil for light or medium duty at low temperatures; containing approved additives to meet specification requirements for oxidation, corrosion and wear (tricresyl phosphate, 0.5% by weight, antiwear agent). The pour point depressant is permitted. This fluid is dyed purple for identification purposes. It has a pour point of -68°C (-90°F) and a viscosity of 600 x 10^{-6} m^2/sec (600 centistokes) at -54°C (-65°F).

Uses: This liquid is used for low temperature hydraulic systems such as missile hydraulic systems, automatic pilots, shock struts, and other hydraulic systems using synthetic sealing material.

Limitations: This liquid is not for high temperature conditions. It is not interchangeable with Hydraulic Fluid, Castor Oil Base, Specification MIH-H-7644 (blue color) nor Hydraulic Fluid, Petroleum Base, Specification MIL-H-5606B.

1.1.33 MIL-L-25681C: Lubricant, Molybdenum Disulfide, Silicone (NATO Code S-1735)

General characteristics: Aircraft gas turbine engine lubricant for sliding surfaces at high temperatures. Composition shall be a 50-50% mixture, by weight of silicone oil and molybdenum disulfide (MIL-M-7866).

Uses: Intended for use in slow-speed sliding surfaces operating at temperatures up to +399°C (+750°F) and as an antiseize compound on threaded parts at temperatures up to +760°C (+1400°F).

Limitations: Material has not been investigated for, and should not be used in, antifriction bearings.

1.1.34 MIL-L-26087B(1): Lubricating Oil, Reciprocating, Ground Support (NATO Code: None)

General characteristics: This specification covers two grades of lubricating oil consisting of highly refined base stock and additives, excluding pour point additives and viscosity index improvers.

Uses: Intended for use in power-driven, high-pressure, reciprocating air compressors at ambient temperatures ranging from -15°C to +54°C (+5°F to +130°F) for Grade I and -4°C to +60°C (+25°F to +140°F) for Grade II.

Limitations: For ground support equipment only. This specification consolidation requirements of MIL-L-26087A (1965) and MIL-L-22396 (1961).

1.1.35 MIL-L-27694A: Lubricating Oil, Instrument, -54°C to +204°C (-65°F to +400°F) (NATO Code: None)

General characteristics: This specification covers one grade of aircraft instrument oil usable over a wide temperature range, -54°C to +204°C (-65°F to +400°F). The composition of this fluid is not limited, but a formulation composed of a nonpetroleum base materials (synthetic) and additives to impart oxidation stability and corrosion-protective properties will be required to meet specification requirements.

Uses: This oil is intended for use in aircraft instruments, such as tachometer generators, gyromotors, gyro gimbals, and other applications involving light to moderate loads, small oscillatory motions, and relatively high speed (up to 24,000 rpm).

Limitations: Oil must be free of any foreign material, no admixtures of resins, rubber, gums, fatty oils, oxidized hydrocarbons, etc.

1.1.36 MIL-L-45199B(1): Lubricating Oil, Internal Combustion Engine (High Output Diesel) (NATO Code: None)

General characteristics: A lubricating oil unrestricted in composition; petroleum product, synthetic or a combination of the two combined with additives (detergent, dispersant, oxidation inhibition, viscosity improvers, etc.) as necessary. Available in two viscosity grades: Grade 10 (Military Symbol HDO-10, NATO Code 0-244; and Grade 30 (Military Symbol HDO-30, NATO Code 0-225).

Uses: Engine oil intended for crankcase lubrication of high output, supercharged compression-ignition engines operating at approximately 150 psi BMEP and above, under all service conditions when ambient temperatures are above -23°C (-10°F).

Limitations: Must not contain any re-refined materials. Must be compatible with other oils to this specification and MIL-L-2104 and MIL-L-21260 oils.

1.1.37 MIL-L-46000A(2): Lubricating Oil, Semi-Fluid (Automatic Weapons) (NATO Code: None)

General characteristics: A special purpose, synthetic lubricating oil of specified composition. The principal components are lithium stearate and bis(2-ethylhexyl)sebacate (synthetic castor oil). Has good lead-carrying capacity, corrosive and rust prevention properties.

Uses: Intended for use in the operation of the M61, M39 and related types of automatic weapons under conditions of extreme pressure and temperature range of -54°C to +127°C (-65°F to +260°F).

1.1.38 MIL-L-46002(ORD): Lubricating Oil, Contact and Volatile, Corrosion Inhibited (NATO Code: None)

General characteristics: This oil is a dual grade volatile corrosion inhibited lubricating oil for preservation of material in enclosed systems. Light and medium viscosity oils are available with pour points of -46°C and -23°C (-50°F and -10°F). This oil is a volatile corrosion inhibited, petroleum base oil containing additives necessary to meet specification requirements. The oil shall contain no ingredients injurious to personnel using reasonable safety precautions and must be free from disagreeable or offensive odors. The operating range is not specified, but the oil or oil-water vapors shall be capable of protecting parts from corrosion throughout a temperature range of +4°C to +54°C (+40°F to +130°F).

Uses: This oil is intended for use in the preservation of enclosed systems where the volatile components will provide protection above the oil level. It is also effective as a contact preservative.

Limitations: The oil is not intended for use as an operational preservative oil and should not be used in applications where magnesium, cadmium-plated or rubber components are present. Generally, it should not be mixed with other oils to same specification due to wide product tolerances.

1.1.39 MIL-L-46017(MR)(1): Lubricating Oil, Machine Tool Slideways (NATO Code: None)

General characteristics: Specification covers three types (three viscosity ranges) of machine tool oil compounded of refined petroleum oil, with or without additives, as necessary. Generally for sliding surfaces.

Uses: The intended usages of the three types of lubricating oil are:

Type I - medium oil; for light to moderate loaded machine tool slideways where an oil in the viscosity range 61 to 75 x 10^{-6} m^2/sec (61 to 75 centistokes) is specified.

Type II - heavy oil; for heavily loaded tool slideways where an oil in the viscosity range 195 to 238 x 10^{-6} m^2/sec (195 to 238 centistokes) is specified.

Type III - heavy oil, special; for heavy loaded tool slideways where an oil in viscosity range 195 to 238 x 10^6 m^2/sec (195 to 238 centistokes) is specified, and operating conditions promote metal pick-up. Also for use on medium and highly loaded ferrous worm-wheels driven by hardened steel worm.

Limitations: These oils may be stored at temperatures from -57°C to +49°C (-70°F to +120°F).

1.1.40 MIL-L-83176: Lubricant, Instrument Bearing, Petroleum Base (NATO Code: None)

General characteristics: Specially refined lubricant, composition limited to a natural paraffinic base stock derived from Pennsylvania Crude Oil and only specified oxidation inhibitor (hindered bis-phenol) and antiwear (tricresyl phosphate) additives. No re-refined products are permitted.

Uses: Intended for use in the spin axis bearings of inertial guidance gyros, accelerometers and other suitable instrument applications.

Limitations: Do not mix with any fluid except those to this specification. Contains tricresyl phosphate and must not be used as medical or food product or in food machinery on surfaces that may contact food.

1.1.41 MIL-L-83767: Lubricating Oil, Vacuum Pump, Mechanical Ejector, Diffusion-Ejector (NATO Code: None)

General characteristics: This specification covers four types (viscosity ranges) of special purpose vacuum pump lubricating oil consisting of a homogeneous blend of highly refined petroleum base stock necessary to meet specification requirements. The four types are: Type I - light viscosity; Type II - medium viscosity; Type III - heavy viscosity, and Type IV - extra heavy viscosity.

Uses: The vacuum pump oils are intended to provide an oil seal, to act as a coolant, and to serve as a lubricant or working fluid for mechanical, ejector, and diffusion-ejector vacuum pumps. The choice of types (viscosity-range) should be in accordance with pump manufacturer's recommendations.

2.1 Lubricating Greases

2.1.1 VV-G-632a(1): Grease, Industrial, General Purpose (NATO Code: None)

General characteristics: This specification covers one type and three grades of lubricating greases intended primarily for lubricating machinery equipped with compression type grease cups. Composition of these greases shall consist of mineral oil base, calcium soap thickener of one or more of the higher fatty acids, with or without additives to meet specification requirements. All grades of this grease are water-resistant and are suitable where moisture is present.

Uses: Grade 1, soft, lubricating grease intended for use where a soft grade (NLGI No. 1) cup grease is specified. Operating temperature range should be -23°C to +49°C (-10°F to +120°F).

Grade 2, medium, lubricating grease intended for use where a medium grade (NLGI No. 2) cup grease is specified. Operating temperature range should be -18°C to +54°C (0°F to 130°F).

Grade 3, hard, lubricating grease intended for use where a hard grade (NLGI No. 3) cup grease is specified. Operating temperature range should be -12°C to +60°C (+10°F to +140°F).

Limitations: None of these specification greases should be used on automatic or artillery equipment. They may not be inhibited against oxidation and may not prevent corrosion under adverse conditions. Automatic and artillery equipment should use MIL-G-10924, Grease, Automatic and Artillery; intended for application formerly covered by Type A (for automatic use), Grades 1, 2, and 3 of VV-G-632 (1948) and can be substituted for these discontinued automatic grades.

2.1.2 MIL-G-3545C(MR): Grease, Aircraft, High Temperature (Military Symbol GH, NATO Code: G-359)

General characteristics: Grease consists of lubricating oil and a gelling agent; has excellent high temperature properties for long periods of service. Good corrosion resistance.

Uses: Intended for use as a lubricant for aircraft accessories operating at high speeds and at temperatures up to -149°C (+300°F). May be used at temperatures down to -40°C (-40°F).

Limitations: Grease must meet specified torque tests at temperatures down to -18°C (0°F); at -40°C (-40°F) its use depends on sufficient available power. A run-in period to properly channel the grease is recommended before attempting very low temperature starts.

2.1.3 MIL-G-4343B: Grease, Pneumatic System (NATO Code: G-392)

General characteristics: Good low temperature properties under both static and dynamic conditions. Lithium soap thickener and a blend of diester and silicone fluid as the base oil. Operational temperature range -54°C to +93°C (-65°F to +200°F).

Uses: This grease is intended for use in pneumatic systems as a lubricant between rubber seals and metal parts (under dynamic conditions). Specification performance tests show that it may be used at pressures up to 11.03 x 10^{-6} N/m^2 (1,600 psi) however, MIL-G-4343 greases have proven satisfactory in service at pressures to 13.79 x 10^{-6} N/m^2 (2,000 psi).

Limitations: This material is suitable for use on Buna N type or Specification MIL-P-5516 rubber. It should not be used with other types of rubber without determining the compatibility between the rubber and grease.

2.1.4 MIL-G-6032B(2): Grease, Plug Valve, Gasoline and Oil Resistant

General characteristics: This specification covers two types of grease resistant to petroleum oils and fuels, made from animal, vegetable, or synthetic oils (i.e., polyester), or a combination thereof, and suitable gelling agent (soap or nonsoap). Contains no fillers such as graphite, mica, clay, etc.

Type I (NATO Code G363) - bulk grease

Type II (No NATO Code) - stick grease

Uses: Intended for use as lubricant on tapered plug valves, gaskets, or seals and other plug value service in systems where resistance to gasoline, oil, alcohol or water is required.

Limitations: Not suitable for use with strong acids, alkalis or hydrogen peroxide.

2.1.5 MIL-G-7187: Grease, Graphite, Aircraft Lubricating

General characteristics: Soap-thickened grease containing graphite and a petroleum oil. Operational temperature range -40°C to +71°C (-40°F to +160°F).

Uses: General aircraft lubricant for sliding surfaces.

Limitations: Contains graphite. Do not use in antifriction bearings or electrical equipment.

2.1.6 MIL-G-10924B: Grease; Automotive and Artillery (NATO Code: None)

General characteristics: Good corrosion resistance including salt spray. Composition not specified but can be a mixture of mineral or synthetic oil or a combination thereof with a suitable thickener. Operational temperature range -54°C to +79°C (-65°F to +175°F).

Uses: Ground handling equipment under all conditions of service for temperatures of -54°C to +52°C (-65°F to 125°F).

Limitations: Not for high temperature use.

2.1.7 MIL-G-14931(MO): Grease, Silicone, for Use with Ammunition (NATO Code: None)

General characteristics: This grease consists of a smooth homogeneous mixture of methyl phenyl silicone and lithium soap. Small portions of additives may be used to improve properties.

Uses: This specification covers a silicone grease for use in ammunition and as waterproofing agent in the M605 mine fuze.

Limitations: This grease must be free of any abrasive, or other undesirable fillers and impurities.

2.1.8 MIL-L-15719A(3): Lubricating Grease (High Temperature Electric Motor, Ball and Roller Bearings) (NATO Code: None)

General characteristics: High temperature silicone grease (Type HTG). Composition consists of polymethylphenyl silicone fluid in a lithium soap thickener. Normal temperature range -18°C to +149°C (0°F to +300°F).

Uses: Intended for lubrication of ball and roller bearings, primarily for lubricating Class H electric motors with heat stabilized ball bearings.

Limitations: It should never be used in areas of sliding metal such as journal bearings, spiral gears or gear trains, etc. Direct contact may irritate eyes.

2.1.9 MIL-G-18709A(3): Grease, Ball and Roller Bearings (NATO Code: None)

General characteristics: Corrosion-inhibited grease consisting of lubricating oil and gelling agents, with or without additives. Composition is not specified. Normal operating temperatures range from 0°C to +107°C (32°F to +225°F) for extended operation and up to +121°C (+250°F) for short periods.

Uses: General use in ball and roller bearings.

Limitations: Not intended for extreme high or low temperature operation.

2.1.10 MIL-G-21164C: Grease, Molybdenum Disulfide, for Low and High Temperatures (Military Symbol GMD, NATO Code 9-358)

General characteristics: This grease consists essentially of a suitable liquid lubricant, a gelling agent, and molybdenum disulfide. The molybdenum disulfide shall conform to MIL-M-7866, and its content by weight shall be not less than 4.5% and not more than 5.5%. This grease has good corrosion protection and water resistance; combined with extreme pressure and under temperature range properties.

Uses: This grease is intended for use as a lubricant for accessory splines, heavily loaded sliding steel surfaces or for antifriction bearing carrying high loads and operating through wide temperature ranges when molybdenum disulfide will prevent or delay seizure in the event of inadequate lubrication. Recommended temperature range 0°C (32°F) to 121°C (+250°F).

Limitations: This grease should not be used for other than steel surfaces without prior performance evaluations.

2.1.11 MIL-G-22615: Grease, Lubricating, for Low and High Temperatures (NATO Code: None)

General characteristics: This specification describes one grade of grease having wide temperature range properties. Composition of this grease shall be a mixture of methyl polysilozane fluid and aryluria bases, free from abrasives and other undesirable fillers or impurities. Small amounts of additives may be included.

Uses: Intended for use in ball and roller bearings and aircraft accessories where operating at both low and high temperatures is required. Operating temperatures range from -54°C to +204°C (-65°F to +40°F).

2.1.12 MIL-G-23549: Grease, General Purpose

General characteristics: Good corrosion resistance, extreme pressure grease. It has a composition of a high viscosity mineral oil with a nonsoap thickener and 5% molybdenum disulfide and a suitable corrosion inhibitor. Normal temperature range up to +177°C (+350°F) for extended periods and to +204°C (+400°F) for short periods.

Uses: This material is intended for use on steam catapult footpad, automotive and ground support equipment. It is intended for use under conditions of high temperature, high load, salt water and contact with live steam.

Limitations: This grease should not be used at temperatures below -18°C (0°F) without prior performance evaluation.

2.1.13 MIL-G-23827A: Grease, Aircraft and Instrument, Gear and Actuator Screw (NATO Code: G-354)

General characteristics: Extreme pressure grease with good corrosion protection. Water resistant with low oil separation. It has a composition of a synthetic base oil with extreme pressure additive in a lithium or calcium stearate or hydroxystearates.

Uses: The grease is intended for use in ball, roller, and needle bearings, gears, and on sliding and rolling surfaces of such equipment as instruments, cameras, electronic gear, and aircraft control systems. It is particularly suitable for equipment which must operate at both low and high temperatures. Its extremely low volatility is of advantage in preventing oil fogging in optical instruments. This grease is also intended for general use on aircraft gears, actuator screws, and other equipment requiring a lubricant with high load-carrying capacity over a temperature range of -54°C (-65°F) to 121°C (+250°F) and for short periods up to 149°C (+300°F). This material replaces MIL-G-3278A, MIL-G-7118A, MIL-G-007118B, and MIL-G-15793.

Limitations: Specification MIL-G-23827 grease contains a relatively low viscosity oil in order to obtain adequate low temperature properties. The low oil viscosity results in a generally higher rate of storage separation or service "bleeding" of the oil components than is generally experienced with high temperature greases such as Specification MIL-G-3545 greases. The special synthetic oils used in this grease may soften paint, natural rubber, neoprene, and electrical insulating materials. Generally, this grease will allow equipment to operate at -54°C (-65°F); however, the increase in torque at -54°C (-65°F), due to the increase in viscosity of this increase, may amount to as much as tenfold over the torque at normal temperatures. This factor must be taken into consideration in the design of equipment.

2.1.14 MIL-G-24139 (Ship)(1): Grease, Multipurpose, Quiet Service (NATO Code: None)

General characteristics: Smooth homogeneous mixture free from lumps, abrasives and undesirable fillers or impurities; consists essentially of a petroleum oil and suitable gelling agent.

Uses: This grease is for multipurpose usage in quiet service. In ball and roller bearings, it may be used for continuous service from 0°C to +106°C (+32°F to +228°F) and for moderate periods up to +121°C (+250°F).

Limitations: Shall have no odor of rancidity or perfume.

2.1.15 MIL-G-25013D: Grease, Aircraft, Ball and Roller Bearing (NATO Code: G-372)

General characteristics: Excellent high temperature properties. This grease shall be a mixture of a suitable liquid lubricant, a gelling agent and additive needed to meet specification requirements. Frequent composition is a nonsoap thickened silicone oil grease.

Uses: This grease is intended for use in ball and roller bearings over the temperature range of -73°C to +232°C (-100°F to +450°F). It is particularly designed for those high temperature ball and roller bearing applications where soap-type thickeners may not be applicable. It will permit operation of equipment at -73°C (-100°F) and will lubricate antifriction bearings continuously at temperatures as high as +232°C (450°F) when the speed factor or DN value of the bearing does not exceed 200,000. This grease replaces that conforming to MIL-G-27343.

Limitations: This grease should not be specified for applications in which the main action involves the sliding of metal-on-metal as in journal bearings, spiral gears, gear trains, and similar applications unless performance evaluation tests have proven it satisfactory.

2.1.16 MIL-G-25537A: Grease, Aircraft, Helicopter Oscillating Bearing (NATO Code G-366)

General characteristics: Good corrosion protection and water resistance. Soft consistency designed to minimize fretting corrosion, composition is not specified. Normal temperature range -54°C to +71°C (-65°F to +160°F) for extended operation and to +93°C (+200°F) for short periods.

Uses: This grease is intended for use in bearings having oscillating motion of small amplitude, such as helicopter rotor head bearings. It is suitable for use in equipment which must operate at ambient temperatures of -54°C to +71°C (-65°F to +160°F).

Limitations: This grease should not be used for ball or roller bearings operating at high speeds or high temperatures.

2.1.17 MIL-G-25760A(3): Grease, Aircraft, Ball and Roller Bearing, Wide Temperature Range (NATO Code: G-361)

General characteristics: Good corrosion protection and water resistance. Excellent high temperature properties, also good high-speed performance. Composition is a synthetic ester base oil in a high melting point gelling agent. Normal temperature range -54°C to +177°C (-65°F to +350°F) for extended periods and to +260°C (+500°F) for short periods.

Uses: This grease is intended for use in ball and roller bearings operating over the temperature range of -54°C to +177°C (-65°F to +350°F). It is particularly suited for wheel bearings in internal brake wheel assemblies of aircraft.

Limitations: This grease should not be used in aircraft actuators, gear boxes and similar equipment unless performance evaluation tests have proven it satisfactory.

2.1.18 MIL-G-27549(1): Grease, Aircraft, Heavy Load Carrying (NATO Code: None)

General characteristics: Wide usable tepmerature range, corrosion inhibited, water resistant and extreme pressure lubricant. Composition consists of a silicone grease with a nonsoap gelling agent. Normal operating temperature range is -54°C to +218°C (-65°F to +425°F).

Uses: This material is intended for use in aircraft actuators, gear boxes, gimbal rings, oscillation bearings and other applications involving heavy loads.

Limitations: This grease should not be used in applications such as antifriction bearings unless performance evaluation tests have proven it satisfactory.

2.1.19 MIL-G-27617A: Grease, Aircraft, Fuel and Oil Resistant (NATO Code: None)

General characteristics: Wide temperature homogeneous compound consisting of a gelling agent and a suitable liquid lubricant. Resistant to fuel, oil and liquid oxygen. Usable at temperatures from -34°C to +204°C (-30°F to +400°F).

Uses: Intended for use in the lubrication of taper plug valves, gaskets, and bearings in fuel systems of aircraft and ground support equipment. Also for use in the presence of liquid oxygen as a lubricant of value, threads and bearings in aerospace vehicles and supporting equipment.

Limitations: May not be suitable for aluminum or magnesium dynamic bearing lubrication because of possible ignition hazards. Not recommended for general antifriction bearing lubrication.

2.1.20 MIL-G-38220(1): Grease, Aircraft, High Speed, Ball and Roller Bearings (NATO Code: None)

General characteristics: Wide temperature grease consisting essentially of a nonsoap gelling agent and a suitable liquid lubricant (i.e., silicone oil base).

Uses: Intended for use in ball and roller bearings over temperature range of -40°C to +200°C (-40°F to +400°F), and DN values up to 400,000. Especially suited for applications in the temperature range where normally soap-type petroleum oil or soap-type synthetic oil greases are not applicable.

Limitations: No corrosion resistance required. For application such as aircraft actuators, gear boxes and similar equipment, performance evaluation tests must prove the lubricant satisfactory before usage.

2.1.21 MIL-G-38277: Grease, Aircraft, High Speed, Ball and Roller Bearing, +316°C (+600°F) (NATO Code: None)

General characteristics: High temperature grease consisting essentially of a nonsoap gelling agent and a suitable liquid lubricant. Similar to MIL-G-38220 but capable of higher temperature operation.

Uses: Intended for use in ball and roller bearings over temperature ranges of -4°C to +315°C (+25°F to 600°F). For use in temperature range where normally soap-type petroleum oil or soap-type synthetic oil greases are not applicable.

Limitations: Must provide at least 100 hr. satisfactory lubrication of a No. 204 open ball bearing operating at 20,000 rpm at a temperature of +314°C (600°F). Use in such applications as aircraft actuators, gear boxes, and similar equipment is recommended only after performance evaluation tests.

2.1.22 MIL-G-46003(MR)(3): Grease, Rifle (NATO Code: None)

General characteristics: A special purpose water-resistant grease. Composed of a stabilized mixture of mineral or synthetic oil and gelling agent, with or without added material necessary to meet specification requirements.

Uses: This grease is intended for lubrication of rifles and other small arms only when they are used under conditions of sustained rain, where conventional oils tend to wash off. Temperature range for use of this grease is +2°C to +38°C (+35°F to +100°F).

Limitations: Not intended as replacement for conventional oils under conditions other than sustained rain.

2.1.23 MIL-G-46006: Grease, Aircraft (NATO Code: None)

General characteristics: Extreme pressure lubricant, water resistant grease. Composition is a mineral oil base with no particular thickener specified. Normal temperature range is 0°C to +135°C (32°F to +275°F).

Uses: Drive shaft couplings, also satisfactory for antifriction bearings.

Limitations: Material does not have good low temperature characteristics.

2.1.24 MIL-G-81322A(1): Grease, Aircraft, General Purpose - Wide Temperature Range (Military Symbol WTR, NATO Code: G-395)

General characteristics: A wide temperature range general purpose grease that consists principally of a wide temperature range liquid lubricant and a high melting point gelling agent. This specification consolidates the requirements of, and in many applications has superseded the following greases: MIL-G-7711A, MIL-G-25760A, and MIL-G-3545.

Use: A general purpose grease applicable where operating temperatures are as low as -54°C (-65°F) and as high as +177°C (+350°F). Specifically designed for wheel bearings in internal brake wheel assemblies, antifriction bearings, gear boxes and plain bearings, also applications such as aircraft accessories operating at high speeds over a wide temperature range.

Limitations: Grease must not have any objectionable odor, or odor of rancidity, perfume, or free alcohol.

2.1.25 MIL-G-83261: Grease, Aircraft, Extreme Pressure, Antiwear (NATO Code: None)

General characteristics: This specification covers one type of heavy load bearing grease consisting essentially of a suitable liquid lubricant, a nonsoap gelling agent, and necessary additives. Has wide range temperature properties.

Uses: Intended for use in aircraft actuators, gear boxes, gimbal rings, oscillation bearings, and other applications involving heavy loads and elevated temperatures.

Limitations: Allowable temperature range from -73°C to +232°C (-100°F to +450°F).

3.1 Compounds

3.1.1 VV-P-236: Petrolatum, Technical (NATO Code: S-743)

General characteristics: This specification covers the requirement for petrolatum that is uniform in quality, clean, homogeneous and refined, and free from adulteration.

Uses: Intended for use as a light grade of lubricating grease, may also be used as a constituent in certain types of rust preventive compounds.

Limitations: Not recommended for use as a lubricant in heavy loaded or hot running bearings.

3.1.2 TT-A-580D(1): Antiseize Compound, General Purpose (for Threaded Fittings) (NATO Code: S-725)

General characteristics: High quality antiseize compound used as sealing compound for steam, water and threaded fittings. Composition is not specified but lead content shall not exceed 1.0% of total solids. Material shall be applicable by paddle at temperatures from -12°C (-10°F) to +60°C (+140°F), shall form a flexible nonshrinking bond that inhibits rust and corrosion and will not gall, seize or block threads.

Uses: General purpose antiseize compound for threaded fittings for steam and water at pressures up to 1.034 x 10^6 N/m^2 (150 psi) and temperatures up to 177°C (350°F). May also be used on flared or cone type fittings in gaseous systems at higher pressures when compatibility exists between the system media and the antiseize compound.

Limitations: Not suitable for use on spark plugs, oxygen systems or hydraulic systems.

3.3.3 MIL-A-907D: Antiseize Compound, High Temperature (NATO Code: None)

General characteristics: This specification covers an antiseize compound of homogeneous mixture, free from ingredients which are corrosive to ferrous metals. Six-month storage life minimum.

Uses: Antiseize compound for use on threads of steel nuts and bolts of super-heated steam installations at temperatures up to 566°C (1050°F).

Limitations: Not intended for use with austenitic steels.

3.1.4 MIL-T-5542D(MI): Thread Compound, Antiseize and Sealing, Oxygen Systems (NATO Code: S-717)

General characteristics: Smooth homogeneous paste of optional composition, but shall contain no mineral, vegetable or animal oils or fats, or other materials which are inflammable with oxygen at 13.79 x 10^6 N/m^2 (2,000 psi). Has excellent high and low temperature sealing properties and good antiseize properties.

Uses: Antiseize and sealing compound intended for use on threaded components of gaseous oxygen systems over a temperature range of -54°C to +71°C (-65°F to +160°F).

Limitations: Not for use with liquid oxygen systems.

3.1.5 MIL-C-5545B: Corrosion Preventive, Aircraft Engine, Heavy Oil Type (NATO Code: None)

General characteristics: Nontoxic heavy oil type corrosion preventive. Easily poured at 710°C (50°F) and flash point more than +177°C (+350°F).

Uses: Compound intended for use on internal parts and surfaces of engines and equipment to prevent damage by corrosion. For static preservation only, and should be removed from engine prior to flight.

Limitations: Material is not for operational use, and should not be confused with MIL-C-6529 lubricant.

3.1.6 MIL-C-8188C: Corrosion Preventive Oil, Gas Turbine Engine, Aircraft Synthetic Base (NATO Code: C-638)

General characteristics: Corrosion-preventive oil which is not limited in composition. Additives necessary to meet specification requirements are permitted.

Uses: Intended for preservation of turboprop and turbojet engines using specifications MIL-L-7808 lubricating oil.

Limitations: Capable of limited use, not exceeding 25 hr., as an aircraft engine lubricant, and can be used for both preservation and final acceptance runs of aircraft engines. Recommended temperature range -54°C to +149°C (-65°F to +300°F).

3.1.7 MIL-S-8660B Silicone Compound (NATO Code: S-736)

General characteristics: This specification covers one type of nonmelting heat stable silicone compound. It is effective in the temperature range 54°C (-65°F) to 204°C (400°F) for extended periods and up to 260°C (500°F) for short periods.

Uses: This material is used as a sealant to prevent galvanic corrosion due to moisture penetration in areas of dissimilar metal contact; for sealing high tension electrical connections of aircraft and automotive engines; sealing and insulating electronic equipment where material must remain in soft state to allow easy disassembly, as a lubricant and sealant for rubber "O" rings and gaskets; when mixed with molybdenum disulfide, for threaded connections on piping and valves that come in contact with corrosive liquids and gases.

Limitations: Not to be used on electrical connectors having natural rubber inserts, as noted in applicable technical orders or specifications for connectors. Not intended for use as a heat sink. Materials having properties more suitable for this application are currently commercially available.

3.1.8 MIL-C-11796 Corrosion Preventive, Petrolatum, Hot Application

General characteristics: This specification covers a suitably formulated petroleum-base corrosion preventive compound, available in three classes. The flash point of this compound is 177°C (350°F) and the melting point is from 57°C (135°F) to 68°C (155°F).

Uses: This material is intended for protection of ferrous and nonferrous metals. Use of this corrosion preventive should be restricted to Class 1 and Class 3 materials. Glass 1 is a hard film compound applied in the molten state by dipping, bushing, swabbing, etc. and may be used for the protection of small metal parts either packaged or unpackaged and for long-term indoor storage protection of highly finished metal parts. Class 3 is a soft film compound applied either by brushing or swabbing at room temperature or by dipping in the molten state and may be used for the preservation of antifriction bearings and on machine surfaces for which a protective material which is easily removable at room temperature is required.

Limitations: Material must not foam or separate after storage at 107°C (225°F) and -40°C (-40°F). Maximum temperature of application are: Class 1 or 1A, 93°C (200°F); Class 2, 88°C (190°F), and Class 3, 82°C (180°F).

3.1.9 MIL-C-16173D(2): Corrosion Preventive Compound, Solvent Cutback, Cold Application (NATO Code: None)

General characteristics: This specification covers one type and five grades of a corrosion preventive compound composed of a nonvolatile base material in a petroleum solvent (no benzol or chlorinated hydrocarbon). Compounds must be free of abrasives, water, chlorides and other impurities, and not injurious to personnel using reasonable care.

Uses: These materials are intended as corrosion preventive compounds which deposit thin, easily removed films after evaporation of solvent. Grade 1 (NATO Code C-632) - provides a hard film for general purpose preservation indoor or outdoor, with or without cover, where a dry-to-touch film is required. Grade 2 (NATO Code C-620) - provides a soft film for extended undercover protection of interior or exterior surfaces of machinery, instruments or bearings with or without barrier materials. Also for outdoor protection of material for limited periods where metal surface temperatures do not cause prohibitive flow of preventive film. Grade 3 - provides a water displacing soft film for use where water or saline solutions must be displaced from corrodible surfaces. For protection of interior surfaces of machinery, instruments and other material under cover for limited periods, and for protection of critical bare steel or phosphated surfaces for extended periods using a barrier material. Grade 4 - provides a transparent non-tacky film for general purpose indoor and outdoor use, where a tack-free coating is required, and where miscibility with lubricating oil is not required and the film must be easily removable with Stoddard's solvent. Grade 5 - low pressure steam removable film for use in place of Grade 3 where chemical "boil-out" cannot be used for removal.

Limitations: Contains combustible petroleum thinner of 38°C (100°F) minimum flash point. Avoid use near open flame, sparks, or welding equipment. Also avoid prolonged or repeated contact with skin or breathing of vapors.

4.1 Hydraulic and Damping Fluids

4.1.1 VV-B-680A - Brake Fluid, Automotive (Military Symbol HB) (NATO Code: H-542)

General characteristics: Specification covers one type and one grade of brake fluid of unrestricted composition, but generally a glycol base.

Uses: Intended for use as an operating fluid in automotive hydraulic systems at ambient temperatures ranging from -40°C (-40°F) to +55°C (131°F), and fluid temperatures from -40°C (-40°F) to 190°C (374°F).

Limitations: Not to be used in preserving brake parts and components in warehouse storage nor in brake systems of vehicles subjected to prolonged periods of standby storage.

4.1.2 VV-D-001078(GSA-FSS): Damping Fluid, Silicone Base (Dimethyl Polysiloxane)

NATO Code	Viscosity Grades: Centistokes or 10^{-6} m^2/sec
S-1714	10
S-1718	50
S-1720	100
S-1724	7,500
S-1726	20,000
S-1728	100,000
S-1732	200,000

General characteristics: This specification includes multigrade silicone damping fluids, based on dimethyl polysiloxane, having a wide range of viscosities--0.65 to 200,000 x 10^{-6} m^2/sec (0.65 to 200,000 centistokes) at 25°C (77°F). These fluids are of high quality, free of suspended matter and water or sediment, and contain no unapproved admixtures or other fluids. This specification supersedes MIL-S-21568A which covered a similar class of damping fluids. Temperature range from -54°C to +316°C (-65°F to +600°F) depending on pour and flash point and viscosity grade.

Uses: These multigrade fluids are intended for many uses such as damping fluids, transducer fluids, lubricants, heat transfer fluids, dielectric fluids, mold release agents, water repellents, hydraulic fluids, protective dressings, and impregnants.

Limitations: These fluids should not be mixed with any other type of lubricating oil or hydraulic fluid. When replacing another oil with this fluid, parts must be disassembled and thoroughly cleaned with fresh solvent. Consideration must be given to the type of elastomer used in contact with the fluids because they tend to cause certain elastomers to shrink and harden. This is particularly true of the lower viscosity fluids.

4.1.3 MIL-H-5606B(3): Hydraulic Fluid, Petroleum Base; Aircraft, Missile, and Ordnance (NATO Code: H-515)

General characteristics: Good low temperature hydraulic fluid that is clear and transparent consisting of petroleum products with additive materials to improve the viscosity-temperature characteristics, resistance to oxidation and antiwear properties. Fluid is dyed red for identification purposes. May be used at temperatures ranging from -54°C to +71°C (-65°F to +160°F) in open systems and up to +135°C (+275°F) in closed airless systems.

Uses: Primarily as an operating oil in aircraft hydraulic systems, automatic pilots, loading gears, shock struts, brakes, flap-control mechanisms, missile hydraulic servo-controlled systems and other hydraulic systems using synthetic sealing materials.

Limitations: Since this fluid has a rather high rate of evaporation, it should not be used as a general-purpose high-temperature lubricant. It is not interchangeable with any other type of hydraulic fluid. Must not contain any pour point depressants.

4.1.4 MIL-H-6083C: Hydraulic Fluid, Petroleum Base, for Preservation and Testing (NATO Code: C-635)

General characteristics: This liquid is a petroleum base corrosion preventive oil for hydraulic equipment. It contains additives to provide corrosion protection and to improve viscosity-temperature characteristics and resistance to oxidation, but no pour point depressant additive is allowed. The fluid shall have no deleterious effect on pressure-seal packing used in aircraft hydraulic systems and shock struts. Operating temperature range is -54°C to +71°C (-65°F to +160°F).

Uses: This fluid is intended as a preservative oil in aircraft and ordnance hydraulic systems during shipment and storage, and also as a testing and flushing liquid for hydraulic system components. It is not intended as an operational hydraulic fluid, but may be used for limited operational use.

Limitations: Not recommended for high temperature use or for heavy duty requirements. This liquid is not interchangeable with hydraulic fluid, castor oil base, Specification MIL-H-7644 (USAF) or hydraulic fluid, nonpetroleum base, automotive, Specification VV-B-680a.

4.1.5 MIL-H-8446B(1): Hydraulic Fluid, Nonpetroleum Base, Aircraft (NATO Code: None)

General characteristics: Wide temperature range, synthetic base oil, hydraulic fluid that has good oxidation stability and antiwear properties. Contains additives to impart oxidation stability, antiwear properties, and viscosity-temperature characteristics necessary to meet specification requirements. Certain disiloxanes containing additives are satisfactory for the rubber swell requirements. Operating temperature range is -54°C to +204°C (-65°F to +400°F).

Uses: This hydraulic fluid is intended for use in high-temperature aircraft hydraulic systems (Type III aircraft hydraulic system as defined in Specification MIL-H-5440), and other systems where a high quality hydraulic fluid is required.

Limitations: The fluid has good storage life and has satisfactory rubber swell properties for type "S" synthetic rubber. It is compatible with other hydraulic fluids to this specification; but not interchangeable with any others. The toxicity characteristics must be furnished.

4.1.6 MIS-10137: Hydraulic Fluid, Petroleum Base, Intermediate Viscosity (NATO Code: None)

General characteristics: This hydraulic fluid is a refined petroleum base liquid with additive materials to improve oxidation resistance, viscosity-temperature characteristics, and tricresyl phosphate for antiwear properties. It is dyed dark green or dark blue for identification purposes. Operating temperature range is not specified. This liquid may also be prepared by blending signal quantities of qualified product list of MIL-H-5606 and MIL-H-46004.

Uses: This hydraulic fluid is for guided missile hydraulic systems such as the Nike Hercules Missile System at intermediate temperatures.

Limitations: This liquid shall contain no pour point depressants, admixtures of resins, rubber, soaps, gums, fatty oils, oxidized hydrocarbons or other additives unless specifically approved. It has a storage life of 12 months under normal conditions, -57°C to +49°C (-70°F to +120°F).

4.1.7 MIS-10150: Hydraulic Fluid, Petroleum Base, Low Temperature, Corrosion Preventing (NATO Code: None)

General characteristics: This liquid is a clear and transparent low temperature petroleum base hydraulic fluid containing polymeric additives to improve viscosity-temperature characteristics, and other additives to inhibit oxidation and corrosion and to improve antiwear properties. It has a pour point of -68°C (-90°F) and a viscosity of 800 x 10^{-6} m^2/sec (800 centistokes) at -54°C (-65°F). Temperature range is not specified but is generally for low temperature applications, -68°C (-90°F) to +95°C (+200°F).

Uses: This hydraulic fluid is intended for use in automatic pilots, shock absorbers, brakes, flap-control mechanisms, missile hydraulic servo-controlled systems, and other hydraulic systems using synthetic sealing materials.

Limitations: This hydraulic fluid is not for high temperature applications, and is not interchangeable with any other hydraulic fluid except as specified in equipment Technical Manuals. It has a normal storage life of 12 months.

4.1.8 MIL-H-13866A(ORD): Hydraulic Fluid, Petroleum Base, Artillery Recoil, Special (NATO Code: None)

General characteristics: This hydraulic fluid is one grade of special recoil hydraulic fluid for shock load mechanisms. The liquid is clear and transparent and is dyed green for identification purposes.

Composition consists of a refined mineral oil, free from resin, soap, unrefined oils and injurious ingredients which may affect the proper function of the fluid. Viscosity index improvers, oxidation inhibitors, and other additives--within defined limits--may be added if needed to meet specification requirements. Usable temperature range is not specified, but generally limited to between -34°C to +93°C (-30°F to 200°F).

Uses: This hydraulic fluid is primarily for ordnance equipment such as hydrosprings and hydropneumatic artillery recoil mechanism. It may also be used in other fluid or force damping mechanisms.

Limitations: This hydraulic fluid is not suitable for extreme temperatures; the fluid, and any of its components, must not be subjected to temperatures above 300°F during blending or subsequent operation.

4.1.9 MIL-H-13910B: Hydraulic Fluid, Polar Type Automotive Brake, All-Weather (NATO Code: None)

General characteristics: This specification covers one type and one grade of all-weather hydraulic brake fluid. Composition is not limited or sprafied but fluids meeting specification requirements are generally glycol base fluids.

Uses: Intended for use in automotive hydraulic brake systems at ambient temperatures ranging from -55°C (-67°F) to +55°C (+131°F).

Limitations: Is not to be used in preserving hydraulic brake parts and components in warehouse storage.

4.1.10 MIL-F-17111(NOrd): Fluid, Power Transmission (NATO Code: H-575)

General characteristics: A petroleum base fluid plus an anti-wear agent, tricresyl phosphate, and other approved additives to improve the fluid with respect to viscosity-temperature and lubricating properties, resistance to oxidation, and corrosion protection. Fluid must be suitable for hydraulic systems employing mechanical or fibrous type filters or centrifugal purification, and shall be noncorrosive to bearings and hydraulic systems and not cause clogging of oil screens or valves. ASTM Color Code No. 2. Usable temperature range not specified but generally between -32°C and +93°C (-35°F and +200°F).

Uses: This fluid is intended for use in connection with the hydraulic transmission of power, particularly in Naval ordnance hydraulic equipment.

Limitations: Not for high temperature applications since fluid is inflammable.

4.1.11 MIL-H-19457B (Ships): Hydraulic Fluid, Fire Resistant (Type I--Low Viscosity, NATO Code H-550; Type II--High Viscosity, NATO Code, None)

General characteristics: These two viscosity grades of non-petroleum base, fire resistant, hydraulic fluids are compositions of phosphoric acid base and such other ingredients as are required to meet specification requirements. These fluids are dyed green for identification. The operating temperature range is not specified, but the fluids are intended for low ambient temperatures; above -18°C (0°F) for Type I and above -4°C (+25°F) for Type II, and for moderate high temperatures to roughly 93°C (+200°F). The minimum compression combustion ratio is 42.0.

Uses: These five resistant hydraulic fluids are intended for use in high-pressure hydraulic systems at moderate temperature ranges, and also for use in air compressors. Also as a lubricant for angular contact ball bearings and should provide at least 50% as good a bearing life as lubricating oil, Military Symbol 2110 H (MIL-L-15017). These fluids are compatible with butyl rubber seals and packing.

Limitations: Material qualified under MIL-H-19457B (Ships) has a low ortho isomer content (TOCP equivalent $\leq$ 25%) in order to pass the specification toxicity requirements. The Bureau of Medicine and Surgery has approved the shipboard use of these qualified products as a result of careful consideration by a committee of competent toxicologists. Containers must be properly marked with warning labels as required by the specification.

WARNING: TOXIC CONTAINS TRIARYL PHOSPHATE. AVOID INHALING, SWALLOWING OR CONTACT WITH SKIN. IN CASE OF CONTACT, REMOVE SOILED CLOTHING AND THOROUGHLY WASH EXPOSED SKIN.

4.1.12 MIL-H-27601: Hydraulic Fluid, Petroleum Base, High Temperature, Flight Vehicle (NATO Code: None)

General characteristics: This liquid is a petroleum or synthetic hydrocarbon base fluid with specified amounts of hindered bisphenol oxidation inhibitor and tricresyl phosphate antiwear additives. No other additives are to be used unless specifically approved. The finished fluid has good thermal and electrical properties and a viscosity index of 89 (min.). Usable temperature range of -40°C to +285°C (-40°F to +550°F).

Uses: This hydraulic fluid is intended for use in high-temperature hydraulic systems, principally for flight vehicles.

Limitations: Not suitable or recommended for very low temperature operation. Also, this fluid is not compatible with any other hydraulic fluids except those meeting this specification.

4.1.13 MIL-H-46001A: Hydraulic Fluid, Petroleum Base, for Machine Tools

	NATO Code	Viscosity Range at 38°C (100°F) 10^{-6} m^2/sec (centistokes)
Type I	None	30-37
Type II	None	42-52
Type III	None	62-70
Type IV	None	106-121

General characteristics: These multigrade hydraulic fluids are a petroleum base fluid and additives necessary to meet specification requirements; i.e., oxidation, pour point, viscosity, foam, etc. All fluids have a viscosity index of 80. Operating temperatures are not specified but ambient temperatures should be above -7°C (+20°F) and the fluids should be satisfactory up to +121°C to +149°C (+250°F to +300°F).

Uses: These hydraulic fluids are intended for use in hydraulic systems of metal working machine tools. The type selected should be based upon the viscosity recommendations of machine tool manufacturers.

Limitations: Not suitable for low temperatures, below -7°C (20°F). Fluids shall contain no admixtures of resins, soaps, germs, fatty acids, nor oxidized hydrocarbons. Do not mix with any other fluids except those to this specification.

4.1.14 MIL-H-46004(Ord): Hydraulic Fluid, Petroleum Base Missile (NATO Code: None)

General characteristics: This specification covers a low viscosity, petroleum base liquid with additives to improve oxidation resistance and antiwear properties (tricresyl phosphate, 0.5 ± 0.1% by weight as the specified antiwear agent). The finished fluid must contain no pour point depressants, viscosity index improvers, admixtures of resins, rubber, soap, gum, fatty oils, oxidized hydrocarbons, nor other additives not approved. This fluid has a viscosity of 300 x 10^{-6} m^2/sec (300 centistokes) at -54°C (-65°F) and a pour point of -59°C (-75°F). The liquid is dyed yellow for identification purposes. Operating temperatures are not specified, but generally are in the range -59°C (-75°F) to -7°C (+20°F).

Uses: This liquid is designed for use in missile hydraulic systems applications at ambient temperatures below -7°C (+20°F).

Limitations: This liquid is not for high temperature or high load applications. It is not interchangeable with Hydraulic Fluid, Castor Base (blue color), Specification MIL-H-7844. This liquid shall not be mixed with, but may be substituted for, Hydraulic Fluid, Petroleum Base, Specification MIL-H-5606B, for low temperature operation. Contains tricresyl phosphate and is harmful if swallowed; keep away from food and food products.

4.1.15 MIL-S-46013(MR): Silicone Fluid, Shock Absorber, Arctic (NATO Code: None)

General characteristics: This specification covers one type of silicone base fluid compounded with appropriate diester lubricant. Viscosity requirements vary from: 120,000 x 10^{-6} m^2/sec (120,000 centistokes) maximum at -55°C (-67°F) to 200 x 10^{-6} m^2/sec (200 centistokes) at 100°C (212°F). Operational fluid temperature range is -55°C to +150°C (-67°F to +302°F).

Uses: This shock absorber fluid is intended for use in rotary shock abosrbers of Army vehicles throughout the specified temperature range.

Limitations: Fluid shall be clean, transparent, and homogeneous, free from water, sediment, suspended matter and undissolved additives.

4.1.16 MIL-P 46046A(MR): Preservative Fluid, Automotive Brake System and Components (NATO Code: None)

General characteristics: This specification covers one type and grade and three compositions of preservative brake fluid. Both the ingredients and quantity of each in the three compositions 1, 2, and 3 are specified. Castor oil is the base fluid for all three compositions. Solvents specified are: Composition 1, 3-methoxy butanol-1; Composition 2, B'methoxymethoxyethanol; Composition 3, diethylene glycol monomethyl ether-ethylene glycol monobutyl ether mixture. Borax-glycol condensate is the specified corrosion inhibitor for all three compositions. The antioxidants specified are: either hydroquinone or 2,5-ditertiarybutal dydroquinone for Compositions 1 and 2; di-t-butyl-p-cresol for Composition 3. Operating temperature range is not specified but is not recommended for low temperatures.

Uses: Intended for use in preserving automotive hydraulic brake systems of vehicles in storage. Also for use as a packaging fluid for both wheel cylinders and master cylinder assemblies. Fluid may also be used as an activating fluid in test stands for testing hydraulic brake parts for flaws and defects. Fluid will perform as a heavy-duty brake fluid at temperatures above -18°C (0°F). This permits the movement of vehicles in limited operation in moderate and warm climates.

Limitations: Avoid prolonged breathing of vapors, and use with adequate ventilation. Avoid repeated or prolonged contact with skin.

4.1.17 MIL-H-81019: Hydraulic Fluid, Petroleum Base, Ultra-Low Temperature (NATO Code: None)

General characteristics: This liquid is a very low temperature, petroleum base, hydraulic fluid containing specified additives to improve viscosity temperature characteristics, oxidation resistance and antiwear properties. The fluid has a pour point of -68°C (-90°F) and a storage life of 12 months. Operating temperature range -68°C to +99°C (-90°F to +210°F).

Uses: Intended for use in automatic pilots, shock abosrbers, brakes, flap-control mechanisms, missile hydraulic servo-controlled systems, and other hydraulic systems using synthetic sealing materials.

Limitations: This fluid is not interchangeable with any other type or grade of hydraulic fluid than Specification MIL-H-5606B which is to be substituted only in emergencies.

4.1.18 MIL-S-81087A: Silicone Fluid, Chlorinated Phenyl Methyl Polysiloxane (NATO Code: H-536)

General characteristics: This specification covers two types of methyl chlorophenyl-polysiloxane fluid for lubrication and other applications over a wide temperature range. It has good thermal stability. Type I fluid is a copolymer containing only dimethyl siloxy and methyl chlorophenyl siloxy units, with trimethyl siloxy terminal groups. Type II fluid is a Type I fluid with the addition of an oxidation inhibitor.

Uses: This fluid is for lubricating, hydraulic damping, and related applications over the temperature range of -73°C to +260°C (-100°F to +500°F), including hydraulic systems and servomechanisms; crankcase and gear boxes for mechanical drives and compressors, engines and pumps; ball, sleeve, and pivot bearings in instruments, electronic equipment, electric motors, etc.; clocks and timing devices; fluid transmissions. Type I is not oxidation inhibited, and in applications where it is exposed to air, the temperature range is -73°C to +218°C (-100°F to +425°F). Type II fluid is inhibited and is suitable for use in oxidative environments over the -97°C to +260°C (-100°F to +500°F) range.

Limitations: Type II fluid, when exposed to temperatures above +260°C (500°F) in an inert atmosphere, has a tendency for the oxidation inhibitor to separate forming a soft gelatinous sludge or precipitate which will not decrease lubricity, but may cause a pressure drop in systems having filters or small orifices. Type II should be reserved for severe and relatively continuous oxidizing environments. Neither type should be mixed with any other lubricating oil or hydraulic fluid. When replacing another oil with this fluid, parts must be disassembled and cleaned with solvents.

4.1.19 MIL-H-83282: Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft

General characteristics: Synthetic hydrocarbon base stock hydraulic fluid containing only specified oxidation inhibitor (phenolic type) and antiwear agent (tricresyl phosphate) additives.

Uses: Fire resistant hydraulic fluid for use in a temperature range from -40°C to +135°C (-40°F to 275°F) in automatic pilots, shock absorbers, brakes, flap-control mechanisms, missile hydraulic fluid servo-controlled systems, and other hydraulic systems using synthetic sealing materials.

Limitations: Not interchangeable with any other type or grade of hydraulic fluid, but shall be miscible with MIL-H-46004 hydraulic fluids. No pour point depressant or viscosity index improver permitted. Do not use in any application where it could, in any way, contaminate foodstuff.

4.1.20 MIL-H-83306(1): Hydraulic Fluid, Fire Resistant, Phosphate Ester Base, Aircraft

General characteristics: Phosphate ester base hydraulic fluid containing additives as necessary to meet the requirements of this specification. The use of dye is allowed.

Uses: This fire resistant hydraulic fluid is intended for use in the temperature range from -54°C (-65°F) to +106°C (+225°F) in aircraft systems.

Limitations: This fluid is not interchangeable with any other type or grade of hydraulic fluid. Not miscible nor compatible with MIL-H-5606 hydraulic fluid nor with synthetic (Buna N) rubber seals used in systems that operate on MIL-H-5606 fluid. Should be stored, covered or uncovered at temperatures from -40°C to +49°C (-40°F to 120°F).

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BIII - LIQUID LUBRICANT DATA SHEETS

FEDERAL SPECIFICATION: VV-L-800A LUBRICATING OIL,

GENERAL PURPOSE, PRESERVATIVE (WATER DISPLACING, LOW TEMPERATURE)

PROPERTIES	SPEC. REQ.	BRAYCO 300*	PETROTECT 800**
GRAVITY, API	-	30.0	-
SPECIFIC GRAVITY, 16°C/16°C (60°F/60°F)	-	0.8762	-
COLOR, ASTM, Max.	7.0	4.0	3.5
FLASH POINT, COC, Min.	135°C (275°F)	146°C (295°F)	143°C (290°F)
POUR POINT, Max.	-57°C (-70°F)	-59°C (-75°F)	< -59°C (< -75°F)
VISCOSITY, 10^{-6} m^2/sec (Cs.)			
at 38°C (100°F), Min.	12	12.87	12.31
at -40°C (-40°F), Max.	7,000	4,868	3,605
at -54°C (-65°F), Max.	60,000	52,313	38,660
PRECIPITATION NUMBER, Max., 10^{-6} m^3 (ml.)	0.05	0.00	OK - trace
CORROSION AND OXIDATION STABILITY, Weight Change, 10^{-10} kg/m^2 (mg/cm^2)			
Copper	± 0.2	0.0	-0.04
Steel	0.2	0.0	-0.02
Aluminum	0.2	0.0	-0.02
Magnesium	0.2	0.0	-0.01
Cadmium	0.2	-0.01	-0.04
Pitting or Etching, Under 20X	None	None	None
Percent Change in Viscosity at 38°C (100°F)	-5 to +20	4.8	+3.3
Increase in Neutralization Number, 10^{-3} kg. KOH/kg (mg. KOH/g) (max.)	0.20	0.05	0.11
Insolubles or Gumming	None	None	None
COPPER CORROSION, ASTM Scale, Max.	3.0	16.0	Pass
EVAPORATION LOSS AT 99°C (210°F), Max., %	18	-	-
CORROSION PROTECTION			
Humidity Cabinet, Sandblasted Steel at 38°C (100°F), 100% Relative Humidity, Days (min.)	8.0	8+	Pass
Water Displacement and Stability			
Oil as Received, Rust or Stains	None	None	None
After Storage with Water, Rust or Stains	None	None	None
Corrosivity, Brass-Steel, 10 Days, 27°C (80°F) and 50% RH	None	None	None
CLOUD INTENSITY, -54°C (-65°F) for 72 hr.			
Gel, Crystals, Solids or Separation	None	None	None
Compared to Turbitary Standard	< Standard	Pass	Pass
FILM CHARACTERISTICS			
No Gum, Tack or Hardness After 24 hr. at 99°C (210°F)	None	None	Pass

FEDERAL SPECIFICATION: VV-L-800A LUBRICATING OIL,

GENERAL PURPOSE, PRESERVATIVE (WATER DISPLACING, LOW TEMPERATURE)

PROPERTIES	SPEC REQ.	BRAYCO 300*	PETROTECT 800**
REMOVABILITY Naphtha Rinse After Humidity Test	Pass	Pass	Pass
MACHINE GUN PERFORMANCE, 0.50 Cal., M-2 at -57°C (-70°F)	No stoppage	Pass	

* Bray Oil Company
** Pennsylvania Refining Company

NOTES: For description of this lubricating oil and recommended usage see Section II.

In addition to the products listed, the following oils supplied by the listed manufacturers meet the general requirements of this specification.

Product Name	Manufacturer
Rust Foil No. 2675	Franklin Oil Corporation
PQ Rust Preventive No. 172	American Oil and Supply Company
Nox-Rust 518, Code R-62-203-1	Daubert Chemical Company
Tectyl 893	Valvoline Oil Company
Royco 308	Royal Lubricants Company

FEDERAL SPECIFICATION: VV-L-825a

LUBRICATING OIL, REFRIGERANT COMPRESSOR, TYPE II

PROPERTIES	SPEC. REQ. TYPE II	CAMPELLA OIL D*	NATOR 825-11**
GRAVITY, API	-	23.6	26.9
SPECIFIC GRAVITY, 16°C/16°C (60°F/60°F)	-	0.9123	0.8933
COLOR, ASTM D1500	Report	-	1.0
FLASH POINT, COC (min.)	177°C (350°F)	204°C (400°F)	204°C (400°F)
POUR POINT (max.)	-32°C (-25°F)	-40°C (-40°F)	-34°C (-30°F)
FLOCK POINT (max.)	-32°C (-25°F)	-	-43°C (-45°F)
VISCOSITY, at 38°C (100°F), 10^{-6} m^2/sec (Cs.)	61.5 to 69.0	65.8	61.5
at 99°C (210°F), 10^{-6} m^2/sec (Cs.)	-	6.5	7.0
VISCOSITY INDEX	-	30	70
REACTION	Neutral	-	-
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g), Max.	0.05	0.02	0.01
DIELECTRIC STRENGTH, 10^3 v. (kv.), Min.	25	-	35
CORROSION (< copper strip, 3 hr. at 100°C (212°F))	Pass	Pass	Pass, 1a
JOURNAL BEARING TEST (200 hr. at 135°C (275°F), 3,500 rpm)	Pass	-	-
CARBON RESIDUE, % Max.	0.3	-	0.002
ASH, % Max.	0.005	-	-

* Texaco, Inc.
** Humble Oil and Refining Company.

NOTES: 1. Type II oil is intended for use with reciprocating-type refrigerant compressor refrigerants (i.e., Freon 12, methylchloride, or ammonia).

2. In addition to Type II, whose specification properties are shown in this table, this specification also covers three other types of oil which have a viscosity range approximately one-half that of Type II, but otherwise have similar properties.

   a. Type I, intended for use with refrigerant compressor systems using sulfur dioxide.
   b. Type II, intended for special applications such as two-stage rotary compressors.
   c. Type IV, intended for use in compressor systems using Freon 22 or similar refrigerants.

3. For description of lubricating oil composition and recommended usage see Section II.

4. In addition to the products listed, the following oils supplied by the listed manufacturers meet the general requirements of this specification; however, no specific data on their properties is available.

Product Name	Manufacturer
Calvis 300	Davis, Howland Oil Corporation
Protexol Refrigerant Compressor Oil, Type II	Golden Bear Oil Company
Camproil 11	Octagon Process, Inc.

FEDERAL SPECIFICATION: VV-L-1071

LUBRICATING OIL, STEAM CYLINDER, MINERAL

PROPERTIES	SPECIFICATION MILITARY SYMBOL 5190	REQUIREMENTS MILITARY SYMBOL 5230
SPECIFIC GRAVITY	-	-
COLOR, ASTM, Max.	-	-
FLASH POINT, Min.	274°C (525°F)	304°C (580°F)
POUR POINT, Max.	16°C (60°F)	16°C (60°F)
VISCOSITY: 10^{-6} m^2/sec (Cs.) at 99°C (210°F)	38.45 - 47.20	47.20 - 51.50
VISCOSITY INDEX	-	90
NEUTRALITY, Qualitative	Neutral	Neutral
ACID AND BASE NUMBER; Max. 10^{-3} kg. KOH/kg (mg. KOH/g)	0.15	0.10
CORROSION: Copper Strip at 100°C (212°F) (ASTM scale)	1 Max.	1 Max.
WATER, %	None	None
ASH, %, Max.	0.05	0.05
CARBON RESIDUE, %, Max.	3.25	3.25
NATURE OF CARBON RESIDUE	Loose & Flaky	Loose & Flaky
TOTAL SULFUR, %, Max.	0.50	0.50
PRECIPITATION NUMBER, Max., 10^{-6} m^3 (ml.)	0.05	0.05
SAPONIFICATION NUMBER, Max.	0.5	0.5
LUBRICANT BASE STOCK	Mineral oil	Mineral oil
ADDITIVES	Pour point Depressant only	Pour point Depressant only

NOTES: For a description of these lubricating oils and recommended usage see Section II.

MILITARY SPECIFICATION: MIL-L-2104B

LUBRICATING OIL, INTERNAL COMBUSTION ENGINE (HEAVY DUTY) GRADE 10

PROPERTIES	SPEC. REQ.	CITGO* 93116 SAE 10W	GULFLUBE** OIL X HD SAE 10W	PHILLIPS 66*** HDS OIL (4414) SAE 10W
GRAVITY, API	-	30.5	30.3	-
FLASH POINT, COC, Min.	182°C (360°F)	199°C (390°F)	216°C (420°F)	204°C (400°F)
FIRE POINT, COC, Min.	-	227°C (440°F)	246°C (475°F)	232°C (450°F)
POUR POINT, Max.	-29°C (-20°F)	-29°C (-20°F)	-	-
STABLE POUR POINT, Max.	-29°C (-20°F)	-29°C (-20°F)	-	-
VISCOSITY, 10^{-6} m^2/sec (Cs.)				
at -18°C (0°F)	2,614	2,614	1,820	-
at 38°C (100°F)	-	35.3 to 37.5	38.6	37.5 to 40.8
at 99°C (210°F)	5.44 to 7.29	5.44 Min.	6.10	6.04 to 6.15
VISCOSITY INDEX	-	100	113	100
FOAM CHARACTERISTICS (Method D 892), 10^{-6} m^3 (ml.) Foam, 10 Min. Settling				
(a) Sequence 1, 24°C (75°F)	300	Pass	5	Pass
(b) Sequence 2, 93°C (200°F)	25	Pass	10	Pass
(c) Sequence 3, 24°C (75°F) (retest)	300	Pass	5	Pass
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g)	-	-	1.7	-
COLOR, ASTM D 1500	Report	4.0	3.0	-
CARBON RESIDUE, %	Present	1.1	0.80	-
OXIDATION CHARACTERISTICS, CLR ENGINE (Method 3405)	Pass	Pass	Pass	Pass
RING, STICK, WEAR AND DEPOSIT FORMATION UNDER HIGH TEMP. (Method 346)	Pass	Pass	Pass	Pass
LOW TEMPERATURE DEPOSIT PROPERTIES (Method 348)	Pass	Pass	Pass	Pass
MOISTURE CORROSION	Pass	Pass	Pass	Pass
VISCOSITY INDEX IMPROVER	-	No	-	-
OXIDATION INHIBITOR	-	Yes	-	Yes
DETERGENT	-	Yes	-	Yes
PHOSPHORUS, %	Present	0.07 to 0.09	0.08	-
CHLORINE (bomb), %	Present	-	Nil	-
SULFUR (bomb), %	Present	0.22 to 0.32	-	-
SULFATED RESIDUE, %	Present	0.75 to 0.90	0.72	-
ZINC, %	Present	0.08 to 0.10	0.08	-

MILITARY SPECIFICATION: MIL-L-2104B

LUBRICATING OIL, INTERNAL COMBUSTION ENGINE (HEAVY DUTY) GRADE 10

PROPERTIES	SPEC. REQ.	CITGO* 93116 SAE 10W	GULFLUBE** OIL X HD SAE 10W	PHILLIPS 66*** HDS OIL (4414) SAE 10W
CALCIUM, %	Present	0.18 to 0.12	Nil	-

* Cities Service Oil Company
** Gulf Research and Development Company
*** Phillips Petroleum Company

NOTES: For description of this lubricating oil and recommended usage, see Section II.

In addition to the products listed, most of the commercial petroleum and lubrication companies manufacture general purpose lubricating oils which meet the requirements of this specification. Some of these are:

AMERICAN SUPERMIL MOTOR OIL, American Oil Company; ATLANTIC MIL-L-2104B OIL, Atlantic Refining Company; BRAYCO 421, Bray Oil Company; FRANKLIN 2104B MOTOR OIL, Franklin Oil Corporation; 2083 MOTOR OIL, Humble Oil and Refining Company; SHELLMIL B OIL, Shell Oil Company; S 600A, S 645A, Socony Mobil Oil Company, Inc.; SUNOCO OCNUS HD, Sun Oil Company; URSA OIL EXTRA DUTY, Texaco, Inc.

MILITARY SPECIFICATION: MIL-L-2104B

LUBRICATING OIL, INTERNAL COMBUSTION ENGINE (HEAVY DUTY), GRADE 30

PROPERTIES	SPEC. REQ.	CITGO* 93116 SAE 30	GULFLUBE** OIL X HD SAE 30	TAGOLINE*** S-2 SAE 30
GRAVITY, API	-	28.5	28.3	28.8
FLASH POINT, COC, Min.	199°C (390°F)	243°C (470°F)	266°C (510°F)	266°C (510°F)
FIRE POINT, COC, Min.	-	277°C (530°F)	291°C (555°F)	-
POUR POINT, Max.	-18°C (0°F)	0	0	0
STABLE POUR POINT, Max.	-	-	-	-
VISCOSITY, 10^{-6} m^2/sec (Cs.)				
at -18°C (0 °F) Max.	43,570	21,700	9,760	13,500
at 38°C (100°F)	-	93	100	115
at 99°C (210°F)	9.65 to 12.98	11.30 to 12.13	11.10	11.9
VISCOSITY INDEX	-	95	103	100
FOAM CHARACTERISTICS (Method D 892), 10^{-6} m^3 (ml.) foam, 10 Min. Settling				
(a) Sequence 1, 24°C (75°F)	300	Pass	5	Pass
(b) Sequence 2, 93°C (200°F)	25	Pass	15	Pass
(c) Sequence 3, 24°C (75°F) (retest)	300	Pass	0	Pass
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g)	-	-	1.7	-
COLOR, ASTM D 1500	Report	5.0	L 3.0	-
CARBON RESIDUE, %	Present	1.1	0.82	0.93
OXIDATION CHARACTERISTICS, CLR ENGINE (Method 3405)	Pass	Pass	Pass	Pass
RING STICK, WEAR AND DEPOSIT FORMATION UNDER HIGH TEMP. (Method 346)	Pass	Pass	Pass	Pass
LOW TEMPERATURE DEPOSIT PROPERTIES (Method 348)	Pass	Pass	Pass	Pass
MOISTURE CORROSION	Pass	Pass	Pass	Pass
VISCOSITY INDEX IMPROVER	-	No	-	-
OXIDATION INHIBITOR	-	Yes	-	-
DETERGENT	-	Yes	-	-
PHOSPHORUS	Present	0.07 to 0.09	0.08	0.07

MILITARY SPECIFICATION: MIL-L-2104B

LUBRICATING OIL, INTERNAL COMBUSTION ENGINE (HEAVY DUTY), GRADE 30

PROPERTIES	SPEC. REQ.	CITGO* 93116 SAE 30	GULFLUBE** OIL X HD SAE 30	TAGOLINE*** S-2 SAE 30
CHLORINE (bomb), %	Present	-	Nil	Nil
SULFUR (bomb), %	Present	0.22 to 0.32	-	0.20
SULFATED RESIDUE, %	Present	0.75 to 0.90	0.72	0.84
ZINC, %	Present	0.08 to 0.10	0.08	0.07
CALCIUM, %	Present	0.18 to 0.22	Nil	0.08

* Cities Service Oil Company
** Gulf Research and Development Company
*** Skelly Oil Company

NOTES: For description of this lubricating oil and recommended usage see Section II.

In addition to the products listed, most of the commercial petroleum and lubrication companies manufacture general purpose lubricating oils which meet the requirements of this specification. Some of these are:

Product Name	Manufacturer
American Supermil Motor Oil	American Oil Company
Atlantic Mil-L-2104B Oil	Atlantic Refining Company
Brayco 423	Bray Oil Company
Franklin 2104B Motor Oil	Franklin Oil Company
2085 Motor Oil	Humble Oil and Refining Co.
Shellmil B Oil	Shell Oil Company
S 600 C, S 645 C	Socony Mobil Oil Co., Inc.
Sunoco Ocnus HD	Sun Oil Company
URSA Oil Extra Duty	Texaco, Inc.

MILITARY SPECIFICATION: MIL-L-2104B

LUBRICATING OIL, INTERNAL COMBUSTION ENGINE (HEAVY DUTY), GRADE 50

PROPERTIES	SPEC. REQ.	CITGO* 93116 SAE 50	GULFLUBE** OIL X HD SAE 50	PHILLIPS 66*** HDS OIL (4454) SAE 50
GRAVITY, API	-	27.0	26.5	-
FLASH POINT, COC, Min.	204°C (400°F)	249°C (480°F)	282°C (540°F)	246°C (475°F)
FIRE POINT, COC, Min.	-	293°C (560°F)	316°C (600°F)	282°C (540°F)
POUR POINT, Max.	-9°C (+15°F)	-15°C (5°F)	-15°C (5°F)	-15°C (5°F)
STABLE POUR POINT, °F Max.	-	-	-	-
VISCOSITY, 10^{-6} m^2/sec (Cs.),				
at -18°C (0°F), Max.	-	-	-	-
at 99°C (210°F)	16.83 to 22.7	19.9 to 21.0	19.9	20.4 to 21.3
at 38°C (100°F)	-	275	247	260 to 28
VISCOSITY INDEX, Min.	75	95	99	95
FOAM CHARACTERISTICS (Method D 892) 10^{-6} m^3 (ml.) Foam, 10 Min. Settling				
(a) Sequence 1, 24°C (75°F)	300	Pass	0	Pass
(b) Sequence 2, 93°C (200°F)	25	Pass	10	Pass
(c) Sequence 3, 24°C (75°F) (retest)	300	Pass	0	Pass
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg KOH/g)	-	-	1.7	-
COLOR, ASTM D 1500	Report	6.0	4.5	-
CARBON RESIDUE, %	Present	1.1	0.98	
OXIDATION CHARACTERISTICS, CLR ENGINE (Method 3405)	Pass	Pass	Pass	Pass
RING, STICK, WEAR AND DEPOSIT FORMATION UNDER HIGH TEMP. (Method 346)	Pass	Pass	Pass	Pass
LOW TEMP. DEPOSIT PROPERTIES (Method 348)	Pass	Pass	Pass	Pass
MOISTURE CORROSION	Pass	Pass	Pass	Pass
VISCOSITY INDEX IMPROVER	-	No	-	-
OXIDATION INHIBITOR	-	Yes	-	Yes
DETERGENT	-	Yes	-	Yes
PHOSPHORUS, %	Present	0.07 to 0.09	0.08	-
CHLORINE (bomb), %	Present	-	Nil	-

MILITARY SPECIFICATION: MIL-L-2104B

LUBRICATING OIL, INTERNAL COMBUSTION ENGINE (HEAVY DUTY), GRADE 50

PROPERTIES	SPEC. REQ.	CITGO* 93116 SAE 50	GULFLUBE** OIL X HD SAE 50	PHILLIPS 66*** HDS OIL (4454) SAE 50
SULFUR (bomb), %	Present	0.22 to 0.32	-	-
SULFATED RESIDUE, %	Present	0.75 to 0.90	0.70	-
ZINC, %	Present	0.08 to 0.10	0.08	-
CALCIUM, %	Present	0.18 to 0.22	Nil	-

* Cities Service Oil Company
** Gulf Research & Development Company
*** Phillips Petroleum Company

NOTES: For description of this lubricating oil and recommended usage see Section II.

In addition to the products listed, most of the commercial petroleum and lubrication companies manufacture general purpose lubricating oils which meet the requirements of this specification. Some of these are:

Product Name	Manufacturer
American Supermil Motor Oil	American Oil Company
Atlantic MIL-L-2104B Oil	Atlantic Refining Company
Brayco 425	Bray Oil Company
Franklin 2104B Motor Oil	Franklin Oil Corporation
2087 Motor Oil	Humble Oil and Refining Company
Shelmil B Oil	Shell Oil Company
S 600E, S 645E	Socony Mobil Oil Company, Inc.
Sunoco Ocnus HD	Sun Oil Company
URSA Oil Extra Duty	Texaco, Inc.

MILITARY SPECIFICATION: MIL-L-2105B

LUBRICATING OIL, GEAR, MULTIPURPOSE, GRADE 80

PROPERTIES	SPEC. REQ.	GULF MULTI-PURPOSE* GEAR LUB. 80	SHELL SPIREX** H.D. 80 59206	MULTIGEAR LUB. EP-80***
GRAVITY, API	-	25.2	23	24.5
FLASH POINT, COC, Min.	163°C (325°F)	196°C (385°F)	193°C (380°F)	204°C (400°F)
FIRE POINT, COC	-	216°C (420°F)	213°C (415°F)	229°C (445°F)
POUR POINT, Max.	-	-34°C (-30°F)	-	-37°C (-35°F)
CHANNEL POINT	-34°C (-30°F)	< -34°C (< -30°F)	-34°C (-30°F)	-34°C (-30°F)
VISCOSITY, -18°C (0°F), 10^{-6} m^2/sec (Cs.), Max.	10,850	8,820	-	6,300
38°C (100°F) (Cs.)	-	80.5	93	83.3
99°C (210°F) (Cs.)	8.8 to 11.6	9.12	9.62	9.79
VISCOSITY INDEX, Min.	-	96	90	104
COPPER CORROSION, D 130, 3 hr. at 121°C (250°F)	< 2 c.	1.0	Pass	1 a.
COLOR, ASTM D 1500	-	L 3.5	7.5	-
SULFUR, %	-	2.11	-	1.3
PHOSPHORUS, %	-	0.14	-	-
CHLORINE, %	-	Trace	-	-
LEAD, %	-	Nil	-	-
ZINC, %	-	Nil	-	-
NITROGEN, %	-	0.053	-	-
CARBON RESIDUE, %	-	0.70	-	-
FOAMING CHARACTERISTICS, 10^{-6} m^3 (ml.) foam after 5.0 min)				
(a) Sequence 1, 24°C (75°F)	300	10	-	0
(b) Sequence 2, 93°C (200°F)	50	15	-	10
(c) Sequence 3, 24°C (75°F) (retest)	300	10	-	0
MOISTURE CORROSION AXLE TEST	Pass	Pass	-	-
THERMAL STABILITY				
(a) Viscosity Increase, 50 hr., %	100	-	-	-
(b) N-Pentane Insolubles, % Weight	3	-	-	-
(c) Benzene Insolubles, % Weight	2	-	-	-
HIGH SPEED SHOCK LOADING	Pass	Pass	-	-

MILITARY SPECIFICATION: MIL-L-2105B

LUBRICATING OIL, GEAR, MULTIPURPOSE, GRADE 80

PROPERTIES	SPEC. REQ.	GULF MULTI-PURPOSE* GEAR LUB. 80	SHELL SPIREX** H.D. 80 59206	MULTIGEAR LUB. EP-80***
AXLE TORQUE TEST				
(a) Untreated Gears	Pass	Pass	-	-
(b) Phosphate Treated Gears	Pass	Pass	-	-
COMPATIBILITY (similar lubricants)	Pass	Pass		

* Gulf Oil Corporation
** Shell Oil Company
*** Texaco, Incorporated

NOTES: For description of this lubricating oil and recommended usage, see Section II.

In addition to the products listed, many of the commercial petroleum and lubrication companies manufacture multipurpose gear lubricants which meet the requirements of this specification; some of these are:

Product	Manufacturer
American Multipurpose Gear Lub. No. 80.	American Oil Company
5420 EP Gear Oil	Humble Oil & Refining Company
Esso Gear Oil GX-80	Humble Oil & Refining Company
PHILUBE 66 Gear Oil SMP	Phillips Petroleum Company
MOTREX 317-SAE 80	Socony Mobil Oil Company, Inc.
SUNOCO Multipurpose Gear Lub. GL-4	Sun Oil Company

MILITARY SPECIFICATION: MIL-L-2105B

LUBRICATING OIL, GEAR, MULTIPURPOSE, GRADE 90

PROPERTIES	SPEC. REQ.	(MP)-90 CITGO PREM. GEAR OIL*	GULF MULTI-PURPOSE** GEAR LUB. 90	TAGOLINE*** MULTIPURPOSE GEAR LUB. GL4
GRAVITY, API	-	26	24.5	24.9
FLASH POINT, COC	177°C (350°F)	182°C (360°F)	218°C (425°F)	338°C (460°F)
FIRE POINT, COC	-	199°C (390°F)	243°C (470°F)	-
POUR POINT, Max.	-	-15°C (5°F)	-9°C (15°F)	-18°C (0°F)
CHANNEL POINT, Max.	-18°C (0°F)	-	< -18°C (< 0°F)	None
VISCOSITY at -18°C (0°F), 10^{-6} m^2/sec (Cs.)	65,000	65,000	40,000	46,000
at 38°C (100°F) (Cs.)	-	238	216	235
at 99°C (210°F) (Cs.)	16.8 to 19.2	18.0 to 19.0	17.3	18.8
VISCOSITY INDEX	-	90	94	92.5
COPPER CORROSION, D 130 (3 hr. at 121°C (250°F)	2 c.	2	1.0	None
COLOR, ASTM D 1500	-	-	L 4.0	-
SULFUR, % Weight	-	2.0 to 2.5	2.10	0.335
PHOSPHORUS, % Weight	-	0.10 to 0.12	0.14	0.38
CHLORINE, %	-	Trace	Trace	1.33
LEAD, %	-	-	Nil	Nil
ZINC, %	-	-	Nil	0.35
NITROGEN, %	-	-	0.053	-
CARBON RESIDUE, %	-	-	0.82	-
FOAMING CHARACTERISTICS (D 892) 10^{-6} m^3 (ml.) Foam After 5.0 Min. Foaming				
(a) Sequence 1, 24°C (75°F)	300	Pass	0	-
(b) Sequence 2, 93°C (200°F)	50	Pass	0	-
(c) Sequence 3, 24°C (75°F) (retest)	300	Pass	0	-
MOISTURE CORROSION AXLE TEST (Method 5326)	Pass	-	Pass	
THERMAL STABILITY (Method 2504)				
(a) Viscosity Increase - 50 hr., %	100	-	-	-
(b) N-Pentane Insolubles, % Weight	3	-	-	0.02
(c) Benzene Insolubes, % Weight	2	-	-	-
HIGH SPEED SHOCK LOADING (Method 6507)	Pass		Pass	-
AXLE TORQUE TEST (Method 6506)				
(a) Untreated Gears	Pass	-	Pass	-
(b) Phosphate-treated Gears	Pass	-	Pass	-

MILITARY SPECIFICATION: MIL-L-2105B

LUBRICATING OIL, GEAR, MULTIPURPOSE, GRADE 90

PROPERTIES	SPEC. REQ.	(MP)-90 CITGO PREM. GEAR OIL*	GULF MULTI-PURPOSE** GEAR LUB. 90	TAGOLINE*** MULTIPURPOSE GEAR LUB. GL4
COMPATIBILITY (similar lubricants)	Pass		Pass	

* Cities Service Oil Company
** Gulf Oil Corporation
*** Skelly Oil Company

NOTES: For description of this lubricating oil and recommended usage see Section II. In addition to the products listed, many of the commercial petroleum and lubrication companies manufacture multipurpose gear lubricants which meet this specification. Some of these are:

Product Name	Manufacturer
American Multi-Purpose Gear Lub. No. 90	American Oil Company
Atlantic Ultragear Oil	Atlantic Refining Company
Esso Gear Oil GX-90	Humble Oil & Refining Company
Philube 66 Gear Oil SMP	Phillips Petroleum Company
Spirex Heavy Duty 90	Shell Oil Company
Motrex 317, SAE 90	Socony Mobil Oil Company, Inc.
Sunoco Multi-Purpose Gear Lub. GL-4	Sun Oil Company
Multigear Lub. EP 90	Texaco, Incorporated

MILITARY SPECIFICATION: MIL-L-2105B

LUBRICATING OIL, GEAR, MULTIPURPOSE, GRADE 140

PROPERTIES	SPEC. REQ.	CITGO PREM. GEAR OIL* (MP)-140	GULF MULTI-PURPOSE** GEAR LUB. 140	MULTIGEAR LUB.*** EP-140
GRAVITY, API	-	25	24.6	21.4
FLASH POINT, COC	191°C (375°F)	191°C (375°F)	213°C (415°F)	216°C (420°F)
FIRE POINT, COC	-	204°C (400°F)	249°C (480°F)	-
POUR POINT, Max.	-	-12°C (10°F)	-18°C (0°F)	-15°C (+5°F)
CHANNEL POINT, Max.	-7°C (20°F)	-7°C (20°F)	< -7°C (< 20°F)	-7°C (20°F)
VISCOSITY, at -18°C (0°F), 10^{-6} m^2/sec (Cs.)	-	-	-	-
at 38°C (100°F) (Cs.)	-	475	497	555
at 99°C (210°F) (Cs.)	25.7 to 34.3	28.6 to 30.4	30.3	28.8
VISCOSITY INDEX	75	90	96	80
COPPER CORROSION, D 130 (3 hr. at 121°C (250°F)	2 c.	2	1.0	1 a
COLOR, ASTM D 1500	-	-	5.0	-
SULFUR, %	-	2.0 to 2.5	2.14	1.3
PHOSPHORUS, %	-	0.10 to 0.12	0.14	-
CHLORINE, %	-	Trace	Trace	-
LEAD, %	-	-	Nil	-
ZINC, %	-	-	Nil	-
NITROGEN, %	-	-	0.053	-
CARBON RESIDUE, %	-	-	0.91	-
FOAMING CHARACTERISTICS (D 892), 10^{-6} m^3 (ml.) Foam After 5.0 Min. Foaming				
(a) Sequence 1, 24°C (75°F)	300	Pass	0	0
(b) Sequence 2, 93°C (200°F)	50	Pass	0	0
(c) Sequence 3, 24°C (75°F) (retest)	300	Pass	0	0
MOISTURE CORROSION AXLE TEST (Method 5326)	Pass	-	Pass	-
THERMAL STABILITY (Method 2504)				
(a) Viscosity Increase - 50 hr., % Change, Max.	100	-	-	-
(b) N-Pentane Insolubles, % Weight	3	-	-	-
(c) Benzene Insolubles, % Weight	2	-	-	-
HIGH SPEED SHOCK LOADING (Method 6507)	Pass	-	Pass	-
AXLE TORQUE TEST (Method 6506)				
(a) Untreated Gears	Pass	-	Pass	-
(b) Phosphate Treated Gears	Pass	-	Pass	-

MILITARY SPECIFICATION: MIL-L-2105B

LUBRICATING OIL, GEAR, MULTIPURPOSE, GRADE 140

PROPERTIES	SPEC. REQ.	CITGO PREM. GEAR OIL* (MP)-140	GULF MULTI-PURPOSE** GEAR LUB. 140	MULTIGEAR LUB.*** EP-140
COMPATIBILITY (similar lubricants)	Pass		Pass	

* Cities Service Oil Company
** Gulf Oil Corporation
*** Texaco, Incorporated

NOTES: For description of this lubricating oil and recommended usage see Section II.

In addition to the products listed, many of the commercial petroleum and lubrication companies manufacture multipurpose gear lubricants which meet the requirements of this specification, some of these are:

Product Name	Manufacturer
American Multi-Purpose Gear Lub No. 140	American Oil Company
Atlantic Ultragear Oil	Atlantic Refining Company
Esso Gear Oil GX-140	Humble Oil and Refining Company
Philube SMP Gear Oil	Phillips Petroleum Company
Spirex Heavy Duty 140	Shell Oil Company
Motrex 317, SAE 140	Socony Mobil Oil Company
Sunoco Multi-Purpose Gear Lub., GL-4	Sun Oil Company
Multigear Lube EP 140	Texaco, Incorporated

MILITARY SPECIFICATION: MIL-L-3918

LUBRICATING OIL, INSTRUMENT, JEWEL BEARING, NONSPREADING, LOW TEMPERATURE

PROPERTIES	SPEC. REQ.	ANDEROL L-416*
SPECIFIC GRAVITY	-	0.94
POUR POINT	-	-54°C (< -65°F)
COLOR, ASTM D 1500	-	3.0
VISCOSITY, at -40°C (-40°F), 10^{-6} m^2/sec (Cs.)	-	1,590
at 18°C (0°F) (Cs.)	-	156
at 38°C (100°F) (Cs.)	9.5 to 10.5	9.9
at 99°C (210°F) (Cs.)	-	2.63
NEUTRALIZATION NUMBER	< 0.60	0.40
EVAPORATION LOSS, 22 hr. at 99°C (210°F), %	< 2	1.7
COPPER STRIP CORROSION, 3 hr. at 100°C (212°F)	Pass	Pass
CORROSION AND OXIDATION STABILITY, 168 hr. at 100°C (212°F) Weight Change, 10^{-10} kg/m^2 (mg/cm^2)		
Aluminum	-	Nil
Copper	0.5	-
Steel	0.5	0.01
Volatile Acids, 10^{-3} kg. KOH/kg (mg. KOH/g) of Oil	0.5	0.5
Color Change	-	Slight
Sludge	-	None
Change in Neutralization Number	0.15	+0.07
Change of Viscosity at 38°C (100°F), %	± 5	0.43
SPREADING ON POLISHED STEEL (30 days)	5%	5%
SPREADING ON POLISHED RUBY (30 days)	-	5%
SPREADING ON POLISHED SAPPHIRE (30 days)	-	5%
LOW TEMPERATURE STABILITY (48 hr. at 40°C (40°F))	Pass	Pass
TYPE OF OIL	-	Diester
USABLE TEMPERATURE RANGE	-	-54°C to 149°C (-65°F to +300°F)

* Lehigh Chemical Company

NOTE: For a description of this medium viscosity nonspreading synthetic diester oil and recommended usage, see Section II.

LUBRICATING OIL, JET ENGINE: GRADE 1010

PROPERTIES	SPEC. REQ.	ESSO TURBO* OIL 10	ROYCO** 460	JET ENGINE*** OIL, MEDIUM
GRAVITY, API	-	-	-	-
SPECIFIC GRAVITY at 16°C (60°F)	-	0.864	-	0.8724
COLOR, ASTM D 1500	5.5	0.5	5.0	Light
FLASH POINT, COC	132°C (270°F)	143°C (290°F)	132°C (270°F)	149°C (300°F)
POUR POINT, COC	-57°C (-70°F)	< -65°C (< -85°F)	-59°C (-70°F)	-59°C (-70°F)
VISCOSITY at -40°C (-40°F) 10^{-6} m^2/sec (Cs.), Max.	3,000	2,442	3,000	2,800
at 38°C (100°F) (Cs.)	10.0	10.1	10	10.2
at 99°C (210°F) (Cs.)	-	2.46	-	2.48
VISCOSITY INDEX	-	79	-	66
VISCOSITY STABILITY, % Change (3 hr. at 4°C (40°F)	2.0	0.01	1.0	
COPPER STRIP CORROSION, ASTM Scale, Max.	1.0	Pass	Pass	1 a
NEUTRALIZATION NUMBER	0.10	0.01	0.10	0.02
PRECIPITATION NUMBER	-	< 0.001	0	0
CORROSION AND OXIDATION STABILITY, 168 hr. at 121°C (250°F) (copper, steel, aluminum alloys, magnesium alloys, and cadmium plated steel), Weight Change, 10^{-10} kg/m^2 (mg/cm^2)	± 0.2	Pass	0.2	< 0.06
Visible Corrosion (20X)	None	None	None	None
Discoloration	Slight	Pass	None	-
Viscosity Change at 38°C (100°F), %	-5 to +20	+3.7	Pass	-
Neutralization Number Increase, Max.	0.20	0.01	0.20	0.02
Insoluble Materials or Gumming	None	Pass	Pass	Pass
OXIDATION INHIBITOR	Allowed	Yes	Yes	Yes
POUR POINT DEPRESSANT	Allowed	Yes	-	Yes
VISCOSITY INDEX IMPROVERS	None	-	-	-

* Humble Oil & Refining Company
** Royal Lubricants Company
*** Texaco, Incorporated

NOTES: For description of the refined petroleum base lubricating oil and recommended usage, see Section II.

In addition to the products listed, many of the commercial petroleum and lubrication companies manufacture jet engine oils which meet the requirements of this specification, some of these are:

Product Name	Manufacturer
31100 Grade 1010	The Atlantic Refining Company
Gulflite, Turbojet Oil 1010	Gulf Oil Company
Kendex 7042	Kendall Refining Company
MacMillan Jet Engine Oil 1010	MacMillan Petroleum Corporation

MILITARY SPECIFICATION: MIL-L-6082-D

LUBRICATING OIL, AIRCRAFT RECIPROCATING ENGINE (PISTON), GRADE 1065

PROPERTIES	SPEC. REQ.	CITGO* 1065 AVIATION OIL	SKELFLITE** 65	1065 AIRCRAFT*** ENGINE OIL
GRAVITY, API	-	29 to 30.4	29.7	30.1
SPECIFIC GRAVITY at 16°C (60°F)	-	-	0.8778	0.8756
COLOR, ASTM D 1500	-	6.0	-	-
FLASH POINT, COC, Min.	205°C (400°F)	216°C (420°F)	238°C (460°F)	249°C (480°F)
POUR POINT (undiluted), Max.	-18°C (0°F)	-18°C (0°F)	-29°C (-20°F)	-26°C (-15°F)
POUR POINT (diluted), Max.	-54°C (-65°F)	-54°C (-65°F)	-57°C (-70°F)	-
VISCOSITY at 38°C (100°F), 10^{-6} m^2/sec (Cs.)	-	110	107.9	111.0
at 54°C (130°F) (Cs.)	-	50.6	48.7	-
at 99°C (210°F) (Cs.)	10.76 to 12.4	11.3 to 12.25	11.48	11.9
VISCOSITY INDEX	100	100	101.6	103
COPPER STRIP CORROSION (3 hr. at 100°C (212°F)	1.0	1.0	Pass	1 a
CARBON RESIDUE, % Max.	0.60	0.30	0.18	0.14
NEUTRALIZATION NUMBER, Max.	0.10	0.10	0.02	0.02
WORK FACTOR	0.85	0.85	-	-
ASH, WEIGHT %, Max.	0.0025	0.0025	0.001	0.001
SULFUR, %, Max.	0.50	0.05 to 0.25	0.14	-
SEDIMENTATION, % Volume, Max.	0.005	0.005	-	-
CONTAMINATION, 10^{-4} kg/m^3 (mg/gal), Max.	39.7 (15.0)	39.7 (15.0)	15.7 (5.94)	-
POUR POINT DEPRESSANT, % Max.	1.0	-	Pass	Pass
OTHER ADDITIVES	None	-	None	None

* Cities Service Oil Company
** Skelly Oil Company
*** Texaco, Incorporated

NOTES: For a description of this petroleum base lubricating oil for reciprocating aircraft engines and recommended usage see Section II.

In addition to the products listed, most of the commercial petroleum and lubrication companies manufacture lubricating oils which meet the requirements of specification. Some of these are:

Product Name	Manufacturer
Esso Aviation Oil 65	Humble Oil & Refining Company
Ser. 0-1065	Kendall Refining Company
Petrolube 1065	Pennsylvania Refining Company
Phillips 66 Aviation Oil, Grade 1065	Phillips Petroleum Company
Aeroshell Oil	Shell Oil Company
Avrex 101/1065	Socony Mobil Oil Company
Formula No. 77675-7L & 8L	Sun Oil Company

MILITARY SPECIFICATION: MIL-L-6082 D

LUBRICATING OIL, AIRCRAFT RECIPROCATING ENGINE (PISTON): GRADE 1100

PROPERTIES	SPEC. REQ.	CITGO* 1100 AVIATION OIL	ESSO** 100 AVIATION OIL	SKELFLITE*** 100
GRAVITY, API	-	27.8 - 29.2	28.3	28.4
SPECIFIC GRAVITY, at 16°C (60°F)	-	-	-	0.8849
COLOR, ASTM D 1500	-	5.0	-	-
FLASH POINT, COC, Min.	243°C (470°F)	277°C (530°F)	279°C (535°F)	268°C (515°F)
POUR POINT (undiluted), Max.	-12°C (+10°F)	-15°C (5°F)	18°C (0°F)	-23°C (-10°F)
POUR POINT (diluted), Max.	-54°C (-65°F)	-54°C (-65°F)	-	-62°C (-80°F)
VISCOSITY, at 38°C (100°F) 10^{-6} m^2/sec (Cs.)	-	259	237.7	253.7
at 54°C (130°F) (Cs.)	-	106	-	92.7
at 99°C (210°F) (Cs.)	18.7 - 21.0	19.42 - 20.4	20.4	19.59
VISCOSITY INDEX	95	95	103	96
COPPER STRIP CORROSION (3 hr. at 100°C (212°F))	1.0	1.0	1.0	Pass
CARBON RESIDUE, %, Max.	1.2	0.25	0.41	0.30
NEUTRALIZATION NUMBER, Max.	0.10	0.10	0.10	0.02
WORK FACTOR	0.85	0.85	-	-
ASH, WEIGHT, %, Max.	0.0025	0.0025	0.0012	0.001
SULFUR, %, Max.	0.5	0.05 - 0.25	0.09	0.17
SEDIMENTATION, % Volume, Max.	0.005	0.005	-	-
CONTAMINATION, 10^{-4} kg/m^3 (mg/gal), Max.	39.7 (15.0)	39.7 (15.0)	-	19.6 (7.4)
POUR POINT DEPRESSANT, Max., %	1.0	-	Pass	-
OTHER ADDITIVES	None	-	None	-

* Cities Service Oil Company
** Humble Oil and Refining Company
*** Skelly Oil Company

NOTES: For a description of this petroleum base lubricating oil for reciprocating aircraft engines and recommended usage see Section II.

In addition to the products listed, most of the commercial petroleum and lubrication companies manufacture lubricating oils which meet the requirements of specification. Some of these are:

Product Name	Manufacturer
Supermil Oil No. 2806	American Oil Company
Atlantic Grade 1100 (No. 43600)	The Atlantic Refining Company
Brayco 480 R	Bray Oil Company
Gulf A-1100	Gulf Oil Corporation
Petrolube 1100	Pennsylvania Refining Company
Phillips 66 Aviation Oil, Grade 1100	Phillips Petroleum Company
Aeroshell Oil 100	Shell Oil Company
Avrex 101/1100	Socony Mobil Oil Company

MILITARY SPECIFICATION: MIL-L-6085A

LUBRICATING OIL, INSTRUMENT, AIRCRAFT, LOW VOLATILITY

PROPERTIES	SPEC. REQ.	BRAYCO* 885	ANDEROL** L 401 D	AEROSHELL FLUID 12
GRAVITY, API	-	-	24.0	21.9
COLOR, ASTM	5.0	2.5	-	2.5
FLASH POINT, COC, Min.	185°C (365°F)	210°C (410°F)	227°C (440°F)	221°C (430°F)
FIRE POINT		-	-	260°C (500°F)
POUR POINT, Max.	-57°C (-70°F)	< -65°C (< -85°F)	-65°C (-85°F)	< -57°C (< -70°F)
VISCOSITY, at -54°C (-65°F) 10^{-6} m^2/sec (Cs.) Max.	12,000	10,800	11,200	10,000
at -40°C (-40°F) (Cs.) Max.	2,000	1,875	-	1,580
at 38°C (100°F) (Cs.)	-	-	12.65	13.8
at 54°C (130°F) (Cs.) Min.	8.0	9.0	8.10	8.55
at 99°C (210°F) (Cs.)	-	-	3.40	3.52
VISCOSITY INDEX	-	-	168	152
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g) Max.	-	Neutral	-	0.20
PRECIPITATION NUMBER	0	Pass	-	Pass
EVAPORATION, %, Max. (22 hr. at 99°C (210°F)	1.0	0.5	0.84	1.0
CARBON RESIDUE, % WEIGHT	-	-	-	0.72
SULFATED RESIDUE, % WEIGHT	-	-	-	0.54
HUMIDITY TEST: 100 hr. 49°C (120°F) 100% RH	Pass		Pass	Pass
LOW TEMPERATURE STABILITY: 72 hr. at -54°C (-65°F)	Pass	Pass		Pass
GALVANIC CORROSION: Steel-Brass, 10 days at 27°C (80°F)	Pass	Pass	Pass	
CORROSION AND OXIDATION STABILITY: 168 hr., Corrosion, Weight Change, 10^{-10} kg/m^2 (mg/sq. cm.)				
Aluminum	0.2	0.0	-	0.0
Copper	0.2	0.1	-	0.1
Magnesium	0.2	0.0	-	0.0
Cadmium Plated Steel	0.2	0.0	-	0.1
Steel	0.2	0.0	-	0.0
Pitting or Etching (Visible, 20X)	None	None	-	Pass
Oxidation Resistance; Viscosity Increase at 54°C (130°F) % Max.	± 5.0	-0.8	-	2.0
Neutralization Number Increase	0.5	0.2	-	0.2

MILITARY SPECIFICATION: MIL-L-6085A

LUBRICATING OIL, INSTRUMENT, AIRCRAFT, LOW VOLATILITY

PROPERTIES		SPEC. REQ.	BRAYCO* 885	ANDEROL** L 401 D	AEROSHELL Fluid 12
ADDITIVES:	Oxidation Stability	Allowed	Yes	-	Yes
	Corrosion Protection	Allowed	Yes	-	Yes
	Viscosity Index Improvers	None	-	-	-
	Pour Point Depressant	None	-	-	-

* Bray Oil Company
** Lehigh Chemical Company
*** Shell Oil Company

NOTE: For a description of this synthetic base lubricating oil composition and recommended usage, see Section II.

In addition to the products listed, the following low volatility oils supplied by the listed manufacturers meet the general requirements of this specifications.

Product Name	Manufacturer
P010K-8	Eclipse-Pioneer Div., Bendix Aviation Corporation
Univis P-38	Humble Oil & Refining Company
Cosmolubric 270A	E. F. Houghton & Company
Nox-Rust 600	Nox-Rust Chemical Corporation
Product 80	Octagon Process, Incorporated
Royco 885	Royal Lubricant Company

MILITARY SPECIFICATION: MIL-L-6086B

LUBRICATING OIL, GEAR, PETROLEUM BASE, GRADE L

PROPERTIES	SPEC. REQ.	CITGO* 6086-L	AEROSHELL** FLUID 5L
GRAVITY, API	-	29.8	27.1
COLOR, ASTM	8.0	4.0	3.0
FLASH POINT, COC, Min.	138°C (280°F)	177°C (350°F)	204°C (400°F)
FIRE POINT, COC, Min.	-	191°C (375°F)	-
POUR POINT, Max.	-40°C (-40°F)	-40°C (-40°F)	-43°C (-45°F)
VISCOSITY at 38°C (100°F), 10^{-6} m^2/sec (Cs.) at 99°C (210°F) (Cs.)	23 to 34 -	22.9 to 25.2 4.27	29.8 4.91
VISCOSITY INDEX	80	90	95
MEAN HERTZ LOAD, Min. (shell 4-ball tester)	392.3 N (40 kg.)	392.3 N (40 kg.)	427.6 N (43.6 kg.)
PRECIPITATION NUMBER, ASTM, Max.	0.10	0.10	Trace
CORROSION, COPPER STRIP, ASTM (3 hr. at 100°C (212°F) max.)	2.0	2.0	1 B
CHLORINE, % Weight	-	-	1.65
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g), Max.	1.0	1.0	< 0.20
COMPATIBILITY (mineral oil base)	Pass	Pass	Pass
VISCOSITY INDEX IMPROVER	-	-	-
EXTREME PRESSURE ADDITIVE	-	Yes	Yes
FOAM TEST, ASTM D 892	Pass	Pass	Pass

* Cities Service Oil Company
** Shell Oil Company

NOTES: For a description of this low temperature mineral oil lubricant and recommended usage see Section II.

In addition to the products listed, the following lubricating oils supplied by the listed manufacturers also meet the general requirements of this specification.

Product Name	Manufacturer
Aircraft Gear Oil - Grade L	Richfield Oil Corporation
Low Temperature Gear Lubricant Grade L	Sinclair Refining Company
Aircraft Gear Oil EP, Light	The Texas Company
70344B	R. M. Hollingshead Corporation

LUBRICATING OIL, GEAR, PETROLEUM BASE, GRADE M

PROPERTIES	SPEC. REQ.	CITGO* NO. 6086-M	AEROSHELL** FLUID 5M
GRAVITY, API	-	27.8	25.1
COLOR, ASTM	8.0	5.5	< 3.5
FLASH POINT, COC, Min.	154°C (310°F)	216°C (420°F)	229°C (445°F)
FIRE POINT, COC, Min.	-	254°C (490°F)	-
POUR POINT, Max.	-29°C (-20°F)	-29°C (-20°F)	-37°C (-35°F)
VISCOSITY, at 38°C (100°F), 10^{-6} m^2/sec (Cs.)	60 to 82	76.6 to 80.9	73.1
99°C (210°F), 10^{-6} m^2/sec (Cs.)	-	8.83	8.5
VISCOSITY INDEX	80	90	94
MEAN HERTZ LOAD, Min.	392.3 N (40 kg.)	392.3 N (40 kg.)	462.9 N (47.2 kg.)
PRECIPITATION NUMBER, ASTM, Max.	0.10	0.10	Trace
CORROSION, COPPER STRIP, ASTM (3 hr. at 100°C (212°F) (max.)	2.0	2.0	1B
CHLORINE, % Weight	-	-	1.67
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g)	1.0	1.0	< 0.20
COMPATIBILITY (mineral oil base)	Pass	Pass	Pass
VISCOSITY INDEX IMPROVER	-	-	-
EXTREME PRESSURE ADDITIVE	-	Yes	Yes
FOAM TEST, ASTM D 892	Pass	Pass	Pass

* Cities Service Oil Company
** Shell Oil Company

NOTES: For a description of this mineral oil general purpose gear lubricant and recommended usage see Section II.

In addition to the products listed, the following lubricating oils supplied by the listed manufacturer also meet the general requirements of this specification.

Product Name	Manufacturer
Aircraft Gear Oil - Grade M	Richfield Oil Corporation
Low Temperature Gear Lubricant, Grade M	Sinclair Refining Company
Aircraft Gear Oil EP Medium	The Texas Company
70344 C	R. M. Hollingshead Corporation

MILITARY SPECIFICATION: MIL-L-7808 (USAF)

LUBRICATING OIL, AIRCRAFT TURBINE ENGINE, SYNTHETIC BASE

PROPERTIES	SPEC. REQ.	STAUFFER* JET I	ROYCO** 808 GF or RH
GRAVITY, API	-	17.5	-
SPECIFIC GRAVITY, 16°C (60°F)	-	0.950	-
FLASH POINT, COC, Min.	204°C (400°F)	232°C (450°F)	221°C (430°F)
FIRE POINT	-	254°C (490°F)	-
AUTOIGNITION POINT	-	460°C (860°F)	-
POUR POINT, Max.	-59°C (-75°F)	< -62°C (< -80°F)	< -65°C (< -85°F)
COLOR, ASTM	-	< 1.0	
VISCOSITY at 38°C (100°F), 10^{-6} m^2/sec			
(Cs.), Min.	11.0	15.2	15.5
99°C (210°F), 10^{-6} m^2/sec (Cs.), Min.	3.0	3.8	4.0
VISCOSITY INDEX	-	160	-
VISCOSITY STABILITY, 3 hr. at -54°C (-65°F)			
Viscosity, -54°C (-65°F), 10^{-6} m^2/sec (Cs.)	< 13,000	11,610	No change
Viscosity Variation, %	± 6.0	+0.3	No change
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg/KOH/g), Max.	0.30	0.08	
CORROSION, 72 hr. at 175°C (347°F),			
Weight Change, 10^{-10} kg/m^2 (mg/cm^2)			
Steel	± 0.2	0.000	0.00
Silver	± 0.2	0.007	0.00
Aluminum Alloy	± 0.2	0.000	0.00
Magnesium Alloy	± 0.2	+0.007	0.00
Copper	± 0.4	-0.062	0.00
PITTING, ETCHING AND VISIBLE CORROSION (20X)	None	Pass	Pass
OXIDATION STABILITY, VISC. CHANGE at 38°C (100°F), %	-5 to +15		
Increase in Neutralization Number	2.0	0.76	0
LEAD CORROSION, 10 hr. at 164°C (325°F), Weight Loss, 10^{-10} kg/m^2 (mg/in^2)	< 6.0	0.0	0.4
SILVER AND COPPER CORROSION, 50 hr. at 232°C (450°F), 10^{-10} kg/m^2 (mg/in^2)	< 3.0	< 0.95	< 0.35
EVAPORATION, 6.5 hr. at 204°C (400°F), Weight Loss, %	35	21.5	19.0

LUBRICATING OIL, AIRCRAFT TURBINE ENGINE, SYNTHETIC BASE

PROPERTIES	SPEC. REQ.	STAUFFER* JET I -	ROYCO** 808 GF or RH
FOAMING CHARACTERISTICS, 10^{-6} m^3 (ml. foam after blowing and time to collapse)			
Sequence 1, 24°C (75°F)	25 (3 min.)	Trace (10 sec.)	0
Sequence 2, 93°C (200°F)	25 (3 min.)	Trace (10 sec.)	0
Sequence 3, 24°C (75°F) (after Seq. 2)	25 (3 min.)	Trace (10 sec.)	0
LOAD CARRYING ABILITY (Ryder), % Ref. Oil, Min.	68	75	88
COMPATIBILITY WITH ELASTOMERS, 168 hr. at 70°C (158°F)			
Rubber "H", Swelling, %	12 to 35	28.8	24.0
Rubber "F", Swelling, %	2 to 35	19.5	-
Tensile Strength Change, %	75	49.6	-
Elongation Change, %	50	21.2	-
Hardness Shore Durameter Number Change	25	17	-
COMPATIBILITY WITH MIL-L-7808 and 6081 OILS	Pass	Pass	Pass
DEPOSITION NUMBER	3.5	1.04	-
RTD PANEL COKER TEST, DEPOSIT WEIGHT, 10^{-6} kg. (mg.)			
8 hr. at 329°C (625°F)	50	Pass	Pass
8 hr. at 357°C (675°F)	175	Pass	Pass
8 hr. at 371°C (700°F)	300	Pass	Pass
STORAGE STABILITY, 110°C (230°F), 2 Days, Lead Corr., 10^{-10} kg/m^2 (mg/in^2)	25	1.8	Pass
7 Days, Lead Corr., 10^{-10} kg/m^2 (mg/in^2)	150	23.5	Pass
EXTENDED STORAGE STABILITY, 12 Months at 24°C (75°F)	No separation	Pass	Pass
100 HR. ENGINE TEST (J-57-19 or -29 Engine)	Pass	Pass	Pass
TRACE SEDIMENT, ml/200 ml. Oil, Max.	0.005	0.00	-

* Stauffer Chemical Company
** Royal Lubricants Company

NOTES: For a description of this synthetic ester base stock lubricant, possessing good thermal and oxidative stability, and recommended usage, see Section II. In addition to the products listed, the lubricant listed below also meets the general requirements of this specification, however, specific properties are not available:

Product Name	*Manufacturer*
Gulf Synthetic Lub. No. 2	Gulf Oil Corporation

Uses: Intended for use in the lubrication of taper plug valves, gaskets, and bearings in fuel systems of aircraft and ground support equipment. Also for use in the presence of liquid oxygen as a lubricant of value, threads and bearings in aerospace vehicles and supporting equipment.

Limitations: May not be suitable for aluminum or magnesium dynamic bearing lubrication because of possible ignition hazards. Not recommended for general antifriction bearing lubrication.

2.1.20 MIL-G-38220(1): Grease, Aircraft, High Speed, Ball and Roller Bearings (NATO Code: None)

General characteristics: Wide temperature grease consisting essentially of a nonsoap gelling agent and a suitable liquid lubricant (i.e., silicone oil base).

Uses: Intended for use in ball and roller bearings over temperature range of -40°C to +200°C (-40°F to +400°F), and DN values up to 400,000. Especially suited for applications in the temperature range where normally soap-type petroleum oil or soap-type synthetic oil greases are not applicable.

Limitations: No corrosion resistance required. For application such as aircraft actuators, gear boxes and similar equipment, performance evaluation tests must prove the lubricant satisfactory before usage.

2.1.21 MIL-G-38277: Grease, Aircraft, High Speed, Ball and Roller Bearing, +316°C (+600°F) (NATO Code: None)

General characteristics: High temperature grease consisting essentially of a nonsoap gelling agent and a suitable liquid lubricant. Similar to MIL-G-38220 but capable of higher temperature operation.

Uses: Intended for use in ball and roller bearings over temperature ranges of -4°C to +315°C (+25°F to 600°F). For use in temperature range where normally soap-type petroleum oil or soap-type synthetic oil greases are not applicable.

Limitations: Must provide at least 100 hr. satisfactory lubrication of a No. 204 open ball bearing operating at 20,000 rpm at a temperature of +314°C (600°F). Use in such applications as aircraft actuators, gear boxes, and similar equipment is recommended only after performance evaluation tests.

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MILITARY SPECIFICATION: MIL-L-9000G (SHIPS)

LUBRICATING OIL, INTERNAL COMBUSTION ENGINE, DIESEL: SYMBOL 9250

PROPERTIES	SPEC. REQ.	CITGO* NO. 93113 GRADE 9250	GULF** 9250	TEXACO*** 9250
GRAVITY, API	-	27.3 - 29.3	28.1	24.9
SPECIFIC GRAVITY, 60°F	-	0.891 - 0.880	0.887	0.9047
FLASH POINT, COC, Min.	199°C (390°F)	232°C (450°F)	268°C (515°F)	235°C (455°F)
FIRE POINT, COC	-	254°C (490°F)	302°C (575°F)	-
POUR POINT, Max.	-12°C (10°F)	-12°C (10°F)	-15°C (+5°F)	-32°C (-25°F)
STABLE POUR POINT, °F, Max.	-	-	-	-
VISCOSITY, 10^{-6} m^2/sec (Cs.)				
at -18°C (0°F)	-	-	-	-
at 38°C (100°F)	-	120.8	128.8	140.0
at 99°C (210°F)	11.9 - 13.5	11.9 - 12.7	12.78	12.4
VISCOSITY INDEX	-	95	99	84
COLOR, ASTM D 1500	-	6.0	3.5	-
COPPER STRIP TEST, 3 hr. at 100°C (212°F)			1.0	1 b
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg. (mg. KOH/g)	-	-	2.10	1.10 Alk.
COMPATIBILITY: (oils of same spec.)	Pass	Pass	Pass	Pass
HOMOGENEITY: (24 hr. at -32°C (-25°F) no separation)	Pass	Pass	Pass	Pass
FOAMING PROPERTIES, Method 3211 10^{-6} m^3 (ml.) Foam After 10 min. Settling				
Sequence 1, at 24°C (75°F) 10^{-6} m^3 (ml.)	300	Pass	0	Pass
Sequence 2, at 93°C (200°F) 10^{-6} m^3 (ml.)	25	Pass	0	Pass
Sequence 3, at 24°C (75°F) (retest) 10^{-4} kg/m^3 (ml.)	300	Pass	0	Pass
CONTAMINATION: Solid Particles, 10^{-4} kg/m^3 (ml/gal) Max.	10	10	1.0	-
Fibrous Material (fibre/gal) Max.	1.0	1.0	Pass	-
Fibre/m^3	264.0	264.0		
SULFUR, Weight %	-	0.32 - 0.46	0.22	-
SULFATED ASH, %	-	0.71	0.63	-
CHLORINE, %	-	-	< 0.05	-
PHOSPHORUS, %	-	-	0.05	-
CALCIUM, %	-	-	0.18	-

MILITARY SPECIFICATION: MIL-L-9000G (SHIPS)

LUBRICATING OIL, INTERNAL COMBUSTION ENGINE, DIESEL: SYMBOL 9250

PROPERTIES	SPEC. REQ.	CITGO* NO. 93113 GRADE 9250	GULF** 9250	TEXACO*** 9250
ZINC, %	-	-	0.06	-
CARBON RESIDUE, %	-	-	0.96	-
ADDITIVES:				
Antioxidants	-	-	Yes	-
Corrosion Inhibitor	-	-	Yes	-
Antirust	-	-	Yes	-
Detergent	-	-	Yes	-
Pressure Carrier	-	-	Yes	-
Pour Point Depressant	-	-	Yes	-
Viscosity Index Improver	-	-	Yes	-
Antifoam	-	-	Yes	-

* Cities Service Oil Company
** Gulf Oil Corporation
*** Texaco, Incorporated

NOTES: For a description of this diesel internal combustion engine lubricating oil and recommended usage see Section II.

In addition to the products listed, many commercial petroleum and lubrication companies manufacture diesel engine lubricating oils which meet the general requirements of this specification. Some of these are:

Product Name	Manufacturer
Supermil Engine Oil No. 0529	American Oil Company
Atlantic 9250	The Atlantic Refining Company
Calol (mil) 9250	Chevron Oil Company
Delta (E) 9250, Five Star 9250	Delta Petroleum Company, Inc.
Nator 9250	Humble Oil & Refining Company
Shell 9250	Shell Oil Company
Standard 9250	Standard Oil of California
DX Motor Oil 9250, DX Marine 9250	Sunray DX Oil Company

MILITARY SPECIFICATION: MIL-L-9236B (USAF)

LUBRICATING OIL, AIRCRAFT TURBINE ENGINE 2040°C (400°F)

PROPERTIES	SPEC. REQ.	CELLUTHERM* 2505A	CELLUTHERM* 2505B
VISCOSITY, 10^{-6} m^2/sec (Cs.)			
at 204°C (400°F)	1	1.25	1.05
at 38°C (100°F)	Report	15.8	15.8
FLASH POINT, Min.	218°C (425°F)	238°C (460°F)	238°C (460°F)
POUR POINT, Min.	-59°C (-75°F)	-68°C (-90°F)	-68°C (-90°F)
SPONTANEOUS IGNITION TEMPERATURE	399°C (750°F)	> 427°C (> 800°F)	> 427°C (> 800°F)
VISCOSITY STABILITY			
Viscosity After 72 hr. at -54°C (-65°F), 10^{-6} m^2/sec (Cs.)	< 24,000	19,000	20,452
EVAPORATION, Max.			
Evaporation Loss During 6-1/2 hr. at 204°C (400°F) (% by weight)	15	6	4
GEAR TESTS			
Load Carrying Ability at 74°C (165°F) (% of Reference Oil B)	56 (min.)	73	65 to 70
Load Carrying Ability at 204°C (400°F)	Report	-	-
Gear Fatigue at 204°C (400°F)	Report	-	-
Swelling of Synthetic Rubbers 204°C (400°F) for 72 hr.			
% Swell (min.)	12	-	-
% Swell (max.)	25	17	15
Foaming Characteristics			
Sequence 1, 10^{-6} m^3 (ml.)	100 (max.)	Trace	Trace
Sequence 2, 10^{-6} m^3 (ml.)	25 (max.)	Trace	Trace
Sequence 3, 10^{-6} m^3 (ml.)	100 (max.)	Trace	Trace
Deposition Number	Report	0.45	1.21
Compatibility with Other Lubricants of Type QPL-7808, MIL-L-9236 and MIL-L-25336	Compatible	Compatible	Compatible
Bearing Stabilization Temperature, Max. (60 max. time of test)	260°C (500°F)	Pass	Pass
Bearing Test (hours)	50 (min.)	Pass	Pass
100-Hr. Engine Endurance Test (oil shall perform as well as or better than the reference oil qualified under this specification)	Pass	Pass	Pass
Storage Stability (after 12 months of storage, 24°C (+75°F) or -21°C (-5°F) the oil shall show no signs of separation and shall meet all specifications except engine test)	Pass	Pass	Pass
Trace Sediment, 10^{-4} kg/m^3 (mg/ml of oil	0.005/200	Pass	Pass

* Celanese Chemical Company

MILITARY SPECIFICATION: MIL-L-10295B

LUBRICATING OIL, INTERNAL-COMBUSTION ENGINE, SUB-ZERO

PROPERTIES	SPECIFICATION REQUIREMENTS
GRAVITY, API	Report
COLOR	-
POUR POINT, Max.	-54°C (-65°F)
STABLE POUR POINT, Max.	-54°C (-65°F)
VISCOSITY, 10^{-6} m^2/sec (Cs.), at 99°C (210°F)	5.75 Min.
at -40°C (-40°F)	8,500 Max.
VISCOSITY INDEX	Report
FLASH POINT, Min.	143°C (290°F)
FOAMING CHARACTERISTICS (Method, ASTM D-892) Immediately Following 5-Min. Bubbling (after 10-min. settling period) Foam Vol., 10^{-6} m^3 or ml.	
a. Sequence 1, 24°C (75°F)	No limit (300)
b. Sequence 2, 93°C (200°F)	No limit (25)
c. Sequence 3, 24°C (75°F)	No limit (300)
OXIDATION CHARACTERISTICS, CLR Engine (FTMS 791, Method 3405)	Noncorrosive
RING STICK, WEAR AND DEPOSIT FORMATION AT ELEVATED TEMPERATURES (FTMS 791, Method 332)	Prevent sticking - nonclogging
STABILITY (FTMS 791, Method 3470)	No separation or color change
COMPATIBILITY (FTMS 791, Method 3470)	No separation or color change
CARBON RESIDUE	Report
PHOSPHOROUS	Report
CHLORINE	Report
SULFUR	Report
SULFATED ASH	Report
METALLIC COMPONENTS	Report
USABLE AT AMBIENT TEMPERATURE RANGE	-18°C to -54°C (0°F to -65°F)
BASE STOCK	Petroleum
ADDITIVES	As required
LIMITATION	No re-refined products

NOTE: For description of this lubricating oil and recommended usage see Section II.

MILITARY SPECIFICATION: MIL-L-11734C

LUBRICATING OIL, SYNTHETIC (FOR MECHANICAL TIME FUZES)

PROPERTIES	SPECIFICATION REQUIREMENTS
SPECIFIC GRAVITY	-
COLOR	-
POUR POINT, Max.	-63°C (-80°F)
VISCOSITY, 10^{-6} m^2/sec (Cs.) at 38°C (100°F)	12.5
at -57°C (-70°F)	15,000
EVAPORATION LOSS, at 99°C (210°F), %	< 1.2
LOW TEMPERATURE STABILITY, 72 hr. at -57°C (-70°F)	No gelling or separation
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g)	Report
OXIDATION STABILITY, 168 hr. at 100°C (212°F)	
Effect on Steel and Copper	None
Appearance	No gumming or separation
Neutralization Number, Increase	0.2
Viscosity Change, at 38°C (100°F), % Max.	± 5.0
Acid Number of Volatile Subst., Max., 10^{-3} kg. KOH/kg (mg. KOH/g)	0.15
CORROSIVITY TEST (FTMS 791, Method 5322) 10 Days, 50% RH at 28°C (80°F)	No pitting, etching or corrosion on two-thirds of specimens, small dots permitted on others.
RUST INHIBITION (48 hr. at 43°C to 54°C (110°F to 130°F)	Pass
COMPOSITION, PERCENT BY WEIGHT	
Di-(2-ethylhexyl)sebacate	32.3 ± 0.5
Di-(2-ethylhexyl)azelate	66.2 ± 1.0
Phenyl-alpha-naphthylamine	0.5 ± 0.1
Barium Petroleum Sulfonate (100% active)	1.0 ± 0.25

NOTE: For description of this lubricating oil and recommended usage see Section II.

MILITARY SPECIFICATION: MIL-O-11773 (ORD)

OIL, LUBRICATING, SYNTHETIC (FOR IMPREGNATING POWDERED METAL SLEEVE BEARINGS)

PROPERTIES	SPEC. REQ.	ROYCO* 871
COLOR:	-	Clear-brown
COMPOSITION:		
OIL: Purfied Di-(2-Ethylhexyl)-Sebacate	Req.	Passes
ADDITIVE: Phenylalpha-Napthylamine % Weight	0.5±0.1	Passes
POUR POINT, (Max.)	-54°C (-65°F)	< -59°C (< -75°F)
EVAPORATION: 22 hr. at 100°C (212°F), % Weight Loss (Max.)	1.0	< 1.0
VISCOSITY: 10^{-6} m^2/sec (Cs.) at -57°C (-70°F) (Max.)	15,000	15,000
at 38°C (100°F)	12.5±1.0	12.5
NEUTRALIZATION NO: 10^{-3} kg. KOH/kg (Mg. KOH/g) (Max.)	0.10	-
LOW TEMPERATURE STABILITY: 48 hr. at -57°C (-70°F) No Gelling or Separation	Pass	Passes
OXIDATION STABILITY: (168 hr. at 100°C (212°F)		
Steel and Copper (no pitting, etch or corrosion)	Pass	Passes
Appearance (no separation or gumming)	Pass	No sludge
Viscosity Change at 38°C (100°F), % Change (max.)	±5.0	< 5.0
Neutralization No. Change; (Max.)	±2.0	-
Acid No. of Volatile Material; 10^{-3} kg. KOH/kg (Mg. KOH/g) (max.)	0.15	-

*Royal Lubricants Company

NOTE: For a description and recommended usage of this low surface tension bearing lubricant, see Section II.

MILITARY SPECIFICATION: MIL-L-15016B

LUBRICATING OIL, GENERAL PURPOSE (MIL. SYMBOL 2110)

PROPERTIES	SPEC. REQ.	CITGO* SENTRY G-2110	NATOR** 2110	CETUS*** OIL 2110
GRAVITY, API	Report	30.9	27.5	21.3
SPECIFIC GRAVITY, 16°C (60°F)	Report	0.871	0.890	0.9260
FLASH POINT, COC, Min.	163°C (325°F)	218°C (425°F)	204°C (400°F)	185°C (365°F)
FIRE POINT	-	252°C (485°F)	-	-
POUR POINT, Max.	-18°C (0°F)	-18°C (0°F)	-37°C (-35°F)	-34°C (-30°F)
VISCOSITY: 10^{-6} m^2/sec				
at 38°C (100°F) (Cs.)	-	44.1	38.7	44
at 54°C (130°F) (Cs.)	5.3 - 6.7	20.6 - 22.8	-	-
at 99°C (210°F) (Cs.)	-	6.19	5.32	5.1
VISCOSITY INDEX	Report	95	66.5	-
COLOR, ASTM D 1500	Report	2.0	-	-
WORK FACTOR, Min.	0.80	0.85	-	-
NEUTRALITY, QUALITATIVE	Neutral	Neutral	-	-
NEUTRALIZATION NUMBER, Max. 10^{-3} kg. KOH/kg (mg. KOH/g)	0.10	0.10		
CORROSION, COPPER STRIP, 3 hr. at 100°C (212°F)	None	1.0	-	1 b
WATER, %, Max.	None	None	-	-
ASH, %, Max.	0.003	0.003	-	-
CARBON RESIDUE, %, Max.	0.20	0.10	-	-
TOTAL SULFUR, %, Max.	0.50	0	-	-
SAPONIFICATION NUMBER, Max.	0.5	0.5	-	-
PRECIPITATION NUMBER, Max.	0.01	0.01	-	-
POUR POINT DEPRESSANT	-	-	-	-
ANTIFOAM ADDITIVE	-	-	-	-

* Cities Service Oil Company
** Humble Oil & Refining Company
*** Texaco, Incorporated

NOTES: For a description of this normal temperature range general purpose, Military Symbol 2110, lubricating oil and recommended usage, see Section II. Symbol Oil 2135 also conforms to the same general specifications but has viscosity and flash points above those for Symbol Oil 2110, however, they are similar in most properties.

In addition to the products listed, most commercial petroleum and lubrication companies manufacture general purpose lubricating oils which meet the requirements of this specification.

LUBRICATING OIL, GENERAL PURPOSE (MIL. SYMBOL 2190)

PROPERTIES	SPEC. REQ.	CITGO* SENTRY G-2190	NATOR** 2190	REGAL*** OIL E-2190
GRAVITY, API	Report	29.6	22.2	22.6
SPECIFIC GRAVITY, 16°C (60°F)	Report	0.8783	0.9206	0.9182
FLASH POINT, COC, Min.	177°C (350°F)	227°C (440°F)	202°C (395°F)	204°C (400°F)
FIRE POINT	-	232°C (500°F)	-	-
POUR POINT, Max.	2°C (35°F)	-15°C (5°F)	-26°C (-15°F)	-29°C (-20°F)
VISCOSITY, at 38°C (100°F), 10^{-6} m^2/sec (Cs.)	-	92.8	109.6	108
at 54°C (130°F) (Cs.)	8.5 to 11.0	41.9 to 44.0	-	-
at 99°C (210°F) (Cs.)	-	10.20	8.68	8.2
VISCOSITY INDEX	Report	95	32.2	-
COLOR, ASTM D 1500	Report	6.0	-	-
WORK FACTOR, Min.	0.80	0.85	-	-
NEUTRALITY, QUALITATIVE	Neutral	Neutral	-	-
NEUTRALIZATION NUMBER, Max. 10^{-3} kg. KOH/kg (mg/KOH/g)	0.10	0.10		0.04
CORROSION, COPPER STRIP, 3 hr. at 100°C (212°F)	None	None	-	1 b
WATER, %, Max.	None	None	-	-
ASH, %, Max.	0.003	0.003	-	-
CARBON RESIDUE, %, Max.	0.40	0.10	-	-
TOTAL SULFUR, %, Max.	0.50	-	-	-
SAPONIFICATION NUMBER, Max.	0.5	0.5	-	-
PRECIPITATION NUMBER, Max.	0.01	0.01	-	-
POUR POINT DEPRESSANT	-	-	-	-
ANTIFOAM ADDITIVE	-	-	-	-

* Cities Service Oil Company
** Humble Oil & Refinery Company
*** Texaco, Incorporated

NOTES: For a description of this normal temperature range, general purpose, Military Symbol 2190, lubricating oil and recommended usage, see Section II. Symbol oil 2250 is similar but has a higher viscosity range and flash point.

In addition to the products listed, most commercial petroleum and lubrication companies manufacture general purpose lubricating oils which meet the requirements of this specification. Some of these are:

Product Name (Military Symbol 2190, 2250)	Manufacturer
Atlantic 1229, 1264	Atlantic Refining Company
Sentry G-2190, G-2250	Cities Service Company
Gulf 2190 Oil, 2250 Oil	Gulf Oil Corporation
Nator 2190, Nator 2250	Humble Oil & Refining Company
Richfield 2190, 2250	Richfield Oil Corporation
Servac 2190, Servac 2250	Socony Mobil Oil Company, Inc.
Standard 2190Q, 2250Q	Standard Oil Company of California

MILITARY SPECIFICATION: MIL-L-15016B

LUBRICATING OIL, GENERAL PURPOSE (MIL. SYMBOL 3050)

PROPERTIES	SPEC. REQ.	CITGO* SENTRY G-3050	GULF** 3050	URSA OIL*** P-20, 3050
GRAVITY, API	Report	30.6	30.4	29.3
SPECIFIC GRAVITY, 16°C (60°F)	Report	0.8729	0.874	0.8800
FLASH POINT, COC, Min.	199°C (390°F)	204°C (400°F)	221°C (430°F)	238°C (460°F)
FIRE POINT	-	227°C (440°F)	246°C (475°F)	-
POUR POINT, Max.	-18°C (0°F)	-18°C (0°F)	-26°C (-15°F)	-21°C (-5°F)
VISCOSITY: 10^{-6} m^2/sec				
at 38°C (100°F) (Cs.)	-	56.7	57.6	73.8
at 54°C (130°F) (Cs.)	-	27.5	28.6	-
at 99°C (210°F) (Cs.)	5.75 - 8.77	6.97 - 8.16	7.94	8.5
VISCOSITY INDEX, Min.	75	100	110	94
COLOR, ASTM D 1500	Report	4.5	L3.0	-
WORK FACTOR, Min.	0.85	0.85	0.95	-
NEUTRALITY, QUALITATIVE	Neutral	Neutral	Neutral	Neutral
NEUTRALIZATION NUMBER, Max. 10^{-3} kg. KOH/kg (mg. KOH/g)	0.10	0.10	0.03	0.03
CORROSION, COPPER STRIP 3 hr. at 100°C (212°F)	None	1.0	1.0	-
WATER, %, Max.	None	None	None	-
ASH, %, Max.	0.003	0.003	0.003	-
CARBON RESIDUE, %, Max.	0.30	0.20	0.18	-
TOTAL SULFUR, %, Max.	0.50	-	0.03	-
SAPONIFICATION NUMBER, Max.	0.5	0.5	0.10	-
PRECIPITATION NUMBER, Max.	0.01	0.01	Nil	-
POUR POINT DEPRESSANT	-	-	-	-
ANTIFOAM ADDITIVE	-	-	-	-

* Cities Service Oil Company
** Gulf Oil Corporation
*** Texaco, Incorporated

NOTES: For a description of this wide temperature range, general purpose, Military Symbol 3050, lubricating oil and recommended usage, see Section II. Symbol oils 3042 and 3065 are similar to 3050 but have viscosity and flash points lower and higher than 3050.

In addition to the products listed, most commercial petroleum and lubrication companies manufacture general purpose lubricating oils which meet the requirements of this specification. Some of these are:

Product Name (Military Symbol 3042, 3050, 3065)	Manufacturer
Atlantic No. 28467, 3050, 3065	Atlantic Refining Company
Sentry G-3042, G-3050, G-3065	Cities Service Oil Company
Gulf 3042, 3050, 3065	Gulf Oil Corporation
Nator 3042, 3050, 3065	Humble Oil & Refining Company

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MILITARY SPECIFICATION: MIL-L-15019C

LUBRICATING OIL, COMPOUNDED: SYMBOL 4065

PROPERTIES	SPEC. REQ.	MARINE ENGINE OIL* 77	CALOL** 4065	MARINE ENGINE OIL*** 4065B
SPECIFIC GRAVITY: 16°C/16°C (60°F/60°F)	Report	0.929	0.923	0.920
API DEGREE	Report	20.9	21.8	22.3
COLOR (ASTM)	Report	L 5.5	4.0	-
COMPOSITION: Base Oil	Petroleum	Petroleum	Naphthenic	-
Compounding Oil; Fatty Oil %	10-20	-	10	-
or Rapeseed Oil %	10-20	-	-	-
Emulsifying Agent	Allowed	Yes	-	-
FLASH POINT, Min.	177°C (350°F)	218°C (425°F)	207°C (405°F)	216°C (420°F)
POUR POINT, Max.	-12°C (10°F)	-21°C (-5°F)	-21°C (-5°F)	-23°C (-10°F)
VISCOSITY, 10^{-6} m^2/sec (Cs.)				
at 99°C (210°F)	11.63 - 15.58	14.26	12.71	12.24
at 54°C (130°F)	-	90.4	-	-
at 38°C (100°F)	-	257	-	182.1
VISCOSITY INDEX	-	32.0	-	44.5
WICK FEED (30% - 2nd day flow on 14th day), Min.	Pass	86%		
EMULSION WITH WATER at 54°C (130°F), Min.	60 min.	80.0		
EMULSION WITH 1% SALT SOLUTION at 54°C (130°F), Min.	60 min.	80.0	-	-
NEUTRALITY, QUALITATIVE	Neutral	Neutral	Neutral	-
NEUTRALIZATION NUMBER; 10^{-3} kg. KOH/kg (mg. KOH/g), Max.	3.0	0.42	0.63	
CORROSION, COPPER STRIP at 100°C (212°F)	Pass	Passes	Passes	
WATER, %, Max.	None	Nil		
ASH: %, Max.	Report	0.005	0.009	
CARBON RESIDUE; %, Max.	1.00	0.26	0.17	-
TOTAL SULFUR, %, Max.	0.75	0.19	0.35	-
PRECIPITATION NUMBER: Max.	0.05	< 0.05	-	
COMPATIBILITY: (other oil per spec.)	Pass	Passes	Passes	
STORAGE STABILITY (6 months)	Pass	Passes	-	

LUBRICATING OIL, COMPOUNDED: SYMBOL 4065

PROPERTIES	SPEC. REQ.	MARINE ENGINE OIL* 77	CALOL** 4065	MARINE ENGINE OIL*** 4065B
FOAM PROPERTIES (Seq. 1 at 24°C (75°F), 2 at 93°C (200°F), 3 at 75°F)				
Foam Immediately After 5 Min. Blow, 10^{-6} m^3 (ml.), Max.	-	130-40-90	-	-
Foam 10.0 Min. Settling, 10^{-6} m^3 (ml.)	-	0-0-0	-	-

* Gulf Oil Company
** Standard Oil of California
*** Humble Oil and Refining Company

NOTES: For a description and recommended usage of this compounded lubricating oil containing petroleum and fatty oils see Section II.

In addition to Symbol Oil 4065, three other grades of Symbol Oils, 6135, 7105 and 8190 are also included in this specification. These oils are of similar composition and properties, but have slightly higher viscosities.

Other compounded lubricating oils which meet the requirements of this specification are:

Product Name	Manufacturer
Neptune 1-Z	Cities Service Oil Company
Protexol Compound Oil	Golden Bear Oil Company
Penn Drake 4065-NS	Pennsylvania Refining Company
Richfield B-4065	Richfield Oil Corporation
Mobil Komo Engine Oil	Socony Mobil Company, Inc.
Sohio 4065 Compound	Standard Oil Company of Ohio
Sunoco 4065 Compound	Sun Oil Company
TL-240-4065	Texaco, Incorporated
Symbol MS-4065	Union Oil Company of California

MILITARY SPECIFICATION: MIL-L-21260

LUBRICATING OIL, INTERNAL-COMBUSTION ENGINE, PRESERVATIVE
GRADE 1 - LIGHT VISCOSITY OIL

PROPERTIES	SPEC. REQ.	CITGO* ANTICORRODE 107 - SAE 10	BRAYCO** 441 SAE 10	PRESERVATIVE OIL*** SAE 10
GRAVITY, API	-	29.6 - 31.6	-	-
COMPOSITION: Oil Type	-	-	Petroleum	Petroleum
Additives	-	-	Rust Preventive Detergent Antioxidant Acid-Neutralizer	
Re-Refined Components	None	None	None	None
FLASH POINT, COC, Min.	192°C (360°F)	204°C (400°F)	204°C (400°F)	204°C (400°F)
POUR POINT, Max.	-29°C (-20°F)	-32°C (-25°F)	-29°C (-20°F)	-40°C (-40°F)
STABLE POUR POINT, Max.	-29°C (-20°F)	-	-29°C (-20°F)	-29°C (-20°F)
VISCOSITY, Kinematic 10^{-6} m^2/sec (Cs.) Max.				
at -18°C (0°F)	2,614	2,614	2,614	-
at 38°C (100°F)	-	39 - 42	-	39.5
at 99°C (210°F)	5.44 - 7.29	5.9 - 6.3	5.76	5.76
VISCOSITY INDEX	-	108	93.3	94.0
FOAMING PROPERTIES: (no foam limit immediately after bubbling period)				
(a) 1st Seq.; at 24°C (75°F) Max. Foam 10.0 min. After Foam Collapse, 10^{-6} m^{-3} (ml.)	300		Negligible	0
(b) 2nd Seq. at 93°C (200°F) Max. Foam 10 min. After Foam Collapse, 10^{-6} m^{-3} (ml.)	25		Negligible	0
(c) 3rd Seq. at 24°C (75°F) Max. Foam 10.0 min. After Foam Collapse 10^{-6} m^{-3} (ml.)	300	-	Negligible	0
VOLATILE MATTER: 4 hr. Steam Bath, % Weight Loss, Max.	2.0	2.0	Passes	
CORROSION PROTECTION: (mild steel spec. oil coated)				
(a) Humidity; 200 hr. at 38°C (100°F), 100% RH; Max. Corrosion "Trace" (3 dots, 1.0 mm. dia.)	Trace	Passes	None	Passes
(b) Salt Water; 20 hr. at 25°C (77°F), Max. Corrosion, "Trace" (3 dots, 1.0 mm. dia.)	Trace	Passes	None	Passes

MILITARY SPECIFICATION: MIL-L-21260

LUBRICATING OIL, INTERNAL-COMBUSTION ENGINE, PRESERVATIVE
GRADE 1 - LIGHT VISCOSITY OIL

PROPERTIES	SPEC. REQ.	CITGO* ANTICORRODE 107 - SAE 10	BRAYCO** 441 SAE 10	PRESERVATIVE OIL*** SAE 10
ACID NEUTRALIZATION (acidic engine comb. products)	Required	Passes	None	Passes
COMPATIBILITY - MIL-L-2104 Oils	Required	-	Passes	Passes
CARBON RESIDUE, %	-	0.19 - 0.39	-	-
SULFATED RESIDUE, %	-	0.25 - 0.32	-	-

* Cities Service Oil Company
** Bray Oil Company
*** Texaco, Incorporated

NOTES: For a description and recommended usage of this preservative lubricating oil, see Section II.

In addition to the products listed, several other petroleum and lubricant companies manufacture products which meet the requirements of this specification. Some of these are:

Product	Manufacturer
Engine Oil No. 9279	Atlantic Refining Company
Conoco 21260	Continental Oil Company
DX Engine Preservative Oil No. 1	DX Sunray Oil Company
Gulf No-Rust Oil, Grade 1	Gulf Oil Corporation
Kendex 7030	Kendall Refining Company
Nox-Rust 235	Nox-Rust Chemical Corporation
Shell Ensis Oil 212	Shell Oil Company
Infilrex 101, SAE 10W	Socony Mobil Oil Company
Supermil Oil No. 06212	American Oil Company
Sunvis 710B	Sun Oil Company
Red Line Z904 Oil	Union Oil Company of California

MILITARY SPECIFICATION: MIL-L-21260

LUBRICATING OIL, INTERNAL-COMBUSTION ENGINE, PRESERVATIVE
GRADE 2 - MEDIUM VISCOSITY OIL

PROPERTIES	SPEC. REQ.	BRAYCO* 443 SAE 30	CITGO** ANTICORRODE 107A - SAE 30	PERSERVATIVE *** OIL SAE 30
GRAVITY, API	-	-	27.6 - 29.6	-
			-	
COMPOSITION: Oil Type	-	Petroleum	-	Petroleum
Additives	-	Rust Preventive	-	-
	-	Detergent	-	-
	-	Antioxidant	-	-
	-	Acid-Neutralizer	-	-
Re-refined Components	None	None	None	None
FLASH POINT - COC, Min.	199°C (390°F)	221°C (430°F)	218°C (425°F)	210°C (410°F)
POUR POINT, Max.	-18°C (0°F)	-23°C (-10°F)	-18°C (0°F)	-29°C (-20°F)
STABLE POUR POINT, Max.	-	-	-	-
VISCOSITY, Kinematic 10^{-6} m^2/sec (Cs.) Max.				
at 18°C (0°F)	43,570	43,570	43,570	43,570
at 38°C (100°F)	-	-	98-128	95.6
at 99°C (210°F)	9.65 - 12.98	10.6	11.5 - 12.0	9.88
VISCOSITY INDEX	-	60.8	100	89
FOAMING PROPERTIES: (no foam limit immediately after bubbling period)				
(a) 1st Seq.; at 24°C (75°F) Max. Foam 10.0 min. After Foam Collapse, 10^{-6} m^3 (ml.)	300	Negligible	Passes	0
(b) 2nd Seq., at 93°C (200°F), Max. Foam 10 min. After Foam Collapse, 10^{-6} m^3 (ml.)	25	Negligible	Passes	0
(c) 3rd Seq., at 24°C (75°F) Max. Foam 10.0 min. After Foam Collapse, 10^{-6} m^3 (ml.)	300	Negligible	Passes	0
VOLATILE MATTER: 4 hr. Steam Bath, % Weight Loss, Max.	2.0	Passes	2.0	
CORROSION PROTECTION: (mild steel spec. oil coated)				
(a) Humidity; 200 hr. at 38°C (100°F), 100% RH; Max. Corrosion "TRACE" (3 dots, 1.0 mm. dia.)	Trace	None	Passes	Passes
(b) Salt Water; 20 hr. at 25°C (77°F), Max. Corrosion, "TRACE" (3 dots, 1.0 mm. dia.)	Trace	None	Passes	Passes
ACID NEUTRALIZATION (acidic engine comb. products)	Required	Passes	Passes	Passes
COMPATIBILITY - MIL-L-2104 Oils	Required	Passes	Passes	Passes

LUBRICATING OIL, INTERNAL-COMBUSTION ENGINE, PRESERVATIVE
GRADE 2 - MEDIUM VISCOSITY OIL

PROPERTIES	SPEC. REQ.	BRAYCO* 443 SAE 30	CITGO** ANTICORRODE - 107A - SAE 30	PRESERVATIVE *** OIL SAE 30
CARBON RESIDUE, %	-	-	0.23 - 0.53	-
SULFATED RESIDUE, %	-	-	0.25 - 0.32	-

* Bray Oil Company
** Cities Service Oil Company
*** Texaco, Inc.

NOTES: For a description and recommended usage of this preservative lubricating oil, see Section II.

In addition to the products listed, several other petroleum and lubricant companies manufacture products which meet the requirements of this specification. Some of these are:

Product	Manufacturer
Engine Oil 9278	Atlantic Refining Company
DX Engine Preservative Oil No. 2	DX Sunray Oil Company
Gulf No-Rust Oil, Grade 2	Gulf Oil Corporation
Kendex 7031	Kendall Refining Company
Nox-Rust 236	Nox-Rust Chemical Corporation
Richlube RP Motor Oil	Richfield Oil Corporation
Shell Ensis Oil 411 & 412	Shell Oil Company
Infilrex 101 SAE 30	Socony Mobil Oil Company
Supermil Oil No. 06212	American Oil Company
Sunvis 730B	Sun Oil Company
Red Line Z904 Oil	Union Oil Company of California

MILITARY SPECIFICATION: MIL-L-21260

LUBRICATING OIL, INTERNAL-COMBUSTION ENGINE, PRESERVATIVE
GRADE 3 - HEAVY VISCOSITY

PROPERTIES	SPEC. REQ.	BRAYCO* 445 SAE 50
GRAVITY, API	-	-
COMPOSITION: OIL TYPE	-	Petroleum
ADDITIVES		Rust Preventive Detergent Antioxidant Acid Neut.
RE-REFINED COMPONENTS	None	None
FLASH POINT - COC, Min.	204°C (400°F)	241°C (465°F)
POUR POINT, Max.	-9°C (+15°F)	-12°C (+10°F)
STABLE POUR POINT, Max.	-	-
VISCOSITY, KINEMATIC, 10^{-6} m^2/sec (Cs.)		
at -18°C (0°F), Max.	-	-
at 38°C (100°F)	-	-
at 99°C (210°F)	16.83 - 22.75	20.6
VISCOSITY INDEX	75	90.0
FOAMING PROPERTIES: (no foam limit immediately after bubbling period) a. 1st Sequence; at 24°C (75°F), Max. Foam 10.0 Min. After Foam Collapse, 10^{-6} m^3 (ml.)	300	Negligible
b. 2nd Sequence; at 93°C (200°F), Max. Foam 10 Min. After Foam Collapse, 10^{-6} m^3 (ml.)	25	Negligible
c. 3rd Sequence, at 24°C (75°F), Max. Foam 10.0 Min. After Foam Collapse, 10^{-6} m^3 (ml.)	300	Negligible
VOLATILE MATTER: 4 hr. Steam Bath, % Weight Loss	2.0	Passes
CORROSION PROTECTION: (mild steel spec. oil coated) a. Humidity: 200 hr. at 38°C (100°F), 100% RH; Max. Corrosion - trace (3 dots, 1.0 mm. dia.)	Trace	None
b. Salt Water; 20 hr. at 25°C (77°F), Max. Corrosion - trace (3 dots, 1.0 mm. dia.)	Trace	None
ACID NEUTRALIZATION (acidic engine comb. products)	Required	Passes
COMPATIBILITY - MIL-L-2104 Oils	Required	Passes
CARBON RESIDUE, %	-	-
SULFATED RESIDUE, %	-	-

*Bray Oil Company

NOTES: For a description and recommended usage of this preservative lubricating oil, see Section II.

In addition to the products listed, several other petroleum and lubricant companies manufacture products which meet the requirements of this specification. Some of these are:

Product	Manufacturer
Gulf No-Rust Oil, Grade 3	Gulf Oil Corporation
Kendex 7032	Kendall Refining Company
Petrotect 21263	Pennsylvania Refining Company
Shell Ensis Oil 413	Shell Oil Company
Infilrex 101 SAE 50	Socony Mobil Oil Company
Supermil Oil No. 06212	American Oil Company

MILITARY SPECIFICATION: MIL-L-23699(B)

LUBRICATING OIL, AIRCRAFT TURBOPROP AND TURBOSHAFT ENGINES, SYNTHETIC BASE

PROPERTIES	SPEC. REQ.	ROYCO* 899	JET II**	TURBO OIL 2380
SPECIFIC GRAVITY, 16°C/16°C (60°F/60°F)	-	-	9.88	0.975
COLOR	-	Light tan	-	-
COMPOSITION, Base Oil Additives	No limit	Steric esters	Diester	Synthetic
		Oxidation		
		Corrosion	-	-
		Antisludge	-	-
FLASH POINT, COC (min.)	246°C (475°F)	246°C (475°F)	257°C (495°F)	249°C (480°F)
POUR POINT, (max.)	-54°C (-65°F)	-80	< -70	< -75
VISCOSITY, 10^{-6} m^2/sec (Cs.)				
at -40°C (-40°F) (max.)	13,000	8,800	9,131	8,816
at 38°C (100°F) (min.)	25.0	27.5	27.6	27.05
at 93°C (210°F)	5.0 to 5.5	5.2	5.23	5.13
VISCOSITY STABILITY (72 hr. at -40°C (-40°F), % Change (max.)	6.0	0	0	0.20
NEUTRALIZATION NUMBER (mg. KOH/g)				
EVAPORATION (6-1/2 hr. at 204°C (400°F)), % Weight Loss (max.)	10.0	4.5	3.6	3.9
FOAMING				
a. 24°C (75°F), Foam After 5.0 min. Aeration, 10^{-6} m^3 (ml.)	25.0	None	Trace	5.0
(max.) 1.0 min. Settling, 10^{-6} m^3 (ml.)	0	None	0	0
b. 93°C (200°F), Foam After 5.0 min. Aeration, 10^{-6} m^3 (ml.)	25.0	None	Trace	10.0
(max.) 1.0 min. Settling, 10^{-6} m^3 (ml.)	0	None	0	0
c. 24°C (75°F) (after test at 93°C (200°F) Foam After 5.0 min. Aeration, 10^{-6} m^3 (ml.) (max.)	25.0	None	Trace	5.0
Foam After 1.0 min. Settling	0	None	0	0
RUBBER SWELL, "H" Synthetic, 72 hr. at 70°C (158°F), %	5 to 25	21.0	24.6	20.6
"F" Synthetic, 72 hr. at 204°C (400°F), %	5 to 25	-	-	16.5
COMPATIBILITY, Oils Per Spec., MIL-L-7808	Pass	Passes	-	Passes

MILITARY SPECIFICATION: MIL-L-23699(B)

LUBRICATING OIL, AIRCRAFT TURBOPROP AND TURBOSHAFT ENGINES, SYNTHETIC BASE

PROPERTIES	SPEC. REQ.	ROYCO* 899	JET II**	TURBO OIL 2380
SEDIMENT, 7 Days at 24°C (75°F), ml/200 ml. (max.)	0.005	-	-	0.001
STORAGE STABILITY (lead corrosion weight loss)				
48 hr. at 110°C (230°F), Weight Loss, mg/in^2 (max.)	25.0	-0.1	-1.19	0.04
168 hr. at 110°C (230°F), Weight Loss, mg/in^2 (max.)	150.0	-1.25	-10.49	43.4
LOW TEMPERATURE STORAGE (6 weeks at -18°C (0°F), No Crystallization, Separation or Gelling	Pass	Passes	Passes	Passes
EXTENDED STORAGE (12 months at 24°C (75°F))	Pass	Passes		Passes
THERMAL STABILITY (24 hr. at 274°C (525°F)				
Viscosity Change at 38°C (100°F), %	5.0	0.75	-1.05	+0.07
Neutralization Number Change (max.)	2.0	1.0	+1.67	+1.26
CORROSION AND OXIDATION STABILITY (72 hr.)				
a. 175°C (347°F);				
Viscosity Change, %	-5 to 15	+8.6	+5.0	+10.0
Neutralization Number Change (max.)	2.0	0.30	0.40	0.47
Weight Change, Steel, Silver	± 0.2	0.02, 0.05	Passes	0.00 to 0.01
10^{-10} kg/m^2 (mg/cm^2)				
Aluminum, Magnesium	± 0.2	0.01, 0.00	Passes	0.00, +0.01
Copper	± 0.4	-0.05	Passes	0.00
b. 204°C (400°F),				
Viscosity Change, %	-5 to 25	+14.0	+19.0	+14.9
Neutralization Number Change (max.)	3.0	0.85	0.75	1.29
Weight Change, Steel, Silver	± 0.2	-0.01 to 0.05	Passes	0.00, 0.00
10^{-10} kg/m^2 (mg/cm^2)				
Aluminum, Magnesium	± 0.2	0.01, -0.06	Passes	0.00, 0.00
Copper	± 0.4	-	Passes	-0.15
Sludge, g/100 ml. (max.)	1.0	0.05	0.0067	-
c. 218°C (425°F),				
Viscosity Change,%	Report	25.0	+24.0	+57.4
Neutralization Number Change	Report	2.4	2.5	5.29
Weight Change, Steel, Silver, Aluminum	-	-0.06, -0.03, 0.01	-	0.01 to 0.15, 0.01
10^{-10} kg/m^2 (mg/cm^2)				
Magnesium, Copper	± 0.2	-0.04, -0.12	-	2.97 to 0.80
Titanium	± 0.2	-	-	-
GEAR TEST (RYDER), % Ref. Oil "HERCOLUBE A" (min.)	102	115	109	112

MILITARY SPECIFICATION: MIL-L-23699(B)

LUBRICATING OIL, AIRCRAFT TURBOPROP AND TURBOSHAFT ENGINES, SYNTHETIC BASE

PROPERTIES	SPEC. REQ.	ROYCO* 899	JET II**	TURBO OIL 2380
BEARING TEST (100 hr. at 138°C (280°F) Deposit				
Dermerit Rating	80.0 (max.)	72.0	66.0	62.3
Filter Deposit, g.	3.0 (max.)	1.8	1.9	0.434
Viscosity Change at 38°C (100°F), %	-5 to 30	12.0	14.5	16.4
Neutralization Number Change	2.0 (max.)	0.3	0.5	0.41
SHEAR STABILITY (sonic test), 30 min. at 38°C (100°F), Viscosity Change, % (max.)	-4.0	0.5	0.7	-0.06
TORBO ENGINE TEST	Pass	Passes	Passes	Passes

* Royal Lubricants
** Stauffer Chemical Company
*** Humble Oil & Refining Company

NOTES: For a description and recommended usage of this high temperature, long-service life, synthetic turbojet engine lubricating oil, see Section II.

In addition to the products listed, other lubricating oils which meet the requirements of this specification are:

Product Name	Manufacturer
Brayco 899G	Bray Oil Company
RM193A and RM147A1	Socony Mobil Oil Company, Inc.
Shellair, Turbine Oil 510	Shell Oil Company, Inc.
HATCOL 3211	Hatco Chemical Division, W. R. Grace & Co.
Sato 5180	Texaco, Inc.

MILITARY SPECIFICATION: MIL-L-25681C

LUBRICATING OIL, MOLYBDENUM DISULFIDE, SILICONE BASE, HIGH TEMPERATURE

PROPERTIES	SPEC. REQ.	ANDEROL* L-751	ROYCO** 81 MS
CONSISTENCY:	-	Thin Paste	-
MOLYBDENUM DISULFIDE, WEIGHT, %	50 ± 1	49.0	Passes
SILICONE OIL (METHYL PHENYL POLYSILOXANE), WEIGHT, %	50 ± 1	50.87	Passes
SODIUM NITRITE, WEIGHT, %	-	0.13	-
SPECIFIC GRAVITY	-	1.7	-
APPEARANCE	-	Grey-Black	-
APPARENT VISCOSITY: at 25°C (77°F), 10^{-6} m^2/sec (Cs.)	-	780	-
at 93°C (210°F), 10^{-6} m^2/sec (Cs.)	-	280	-
COPPER CORROSION	-	Passes	-
HUMIDITY CABINET	-	Passes	-
TEMPERATURE RANGE:			
SLOW SPEED SLIDING SURFACES	399°C (750°F)	Passes	Passes
ANTISEIZE, THREADS	760°C (1400°F)	Passes	Passes
SILICONE OIL CHARACTERISTICS:			
COLOR, ASTM D 1500, Max.	2.0	1.5	Passes
FLASH POINT, min.	274°C (525°F)	307°C (585°F)	Passes
POUR POINT,	-	-43°C (-45°F)	-
VISCOSITY; at 38°C (100°F), 10^{-6} m^2/sec (Cs.)	65 - 85	75	Passes
at 99°C (210°F) (Cs.)	16 - 22	18	Passes
EVAPORATION: at 205°C (400°F), %	-	1.8	-
REFRACTIVE INDEX: at 25°C (77°F)	-	1.49	-

* Lehigh Chemical Company.
** Royal Lubricants Company.

NOTE: For a description of this high temperature heavy oil or light grease and recommended usage, see Section II.

LUBRICATING OIL, RECIPROCATING COMPRESSOR, GROUND SUPPORT

PROPERTIES	SPEC. REQ. GRADE I*	COSMOLUBRIC** 677	ROYCO*** 487
SPECIFIC GRAVITY	-	-	-
FLASH POINT, Min.	188°C (370°F)	210°C (410°F)	193°C (380°F)
POUR POINT, Max.	-21°C (-5°F)	-23°C (-10°F)	-26°C (-15°F)
AUTOIGNITION TEMPERATURE, Min.	316°C (600°F)	-	343°C (650°F)
VISCOSITY, 10^{-6} m^2/sec			
at 38°C (100°F) (Cs.)	105-135	110.1	120
at 99°C (210°F) (Cs.)	8-11	9.3	9.5
COLOR, ASTM	5.0	5.0	-
CARBON RESIDUE, %, Max.	0.20	-	0.15
NEUTRALIZATION NUMBER: 10^{-3} kg. KOH/kg (mg. KOH/g)	0.10		0.05
TRACE SEDIMENT, %, Max.	0.05		-
COPPER STRIP CORROSION: 3 hr. at 100°C (212°F) (ASTM)	2.0		No stain
FOAMING CHARACTERISTICS: (D892)			
Foam After 5 min. Blowing			
1. Sequence 1, at 24°C (75°F) 10^{-6} m^3 (ml.)	300		
2. Sequence 2, at 93°C (200°F) 10^{-6} m^3 (ml.)	100	-	
3. Sequence 3, at 24°C (75°F) (retest) 10^{-6} m^3 (ml.)	300	-	
Foam After 10 min. Settling			
1. Sequence 1, 10^{-6} m^3 (ml.)	0	-	-
2. Sequence 2, 10^{-6} m^3 (ml.)	0	-	-
3. Sequence 3, 10^{-6} m^3 (ml.)	0	-	-
STORAGE STABILITY: 6 Months at 24°C (75°F) (separation)	None	-	Stable
COMPATIBILITY: (other compressor oils)	Yes	-	Passes
COMPRESSOR LUBRICATION TEST: 500 hr.	Pass	-	Passes
COMPOSITON:			
Base Stock	-	Naphthenic	Naphthenic
Additives	-	Yes	Yes
TEMPERATURE RANGE	-	-	-18°C - +54°C (0°F - +130°F)

* Grade II finished oil is a higher viscosity oil with similar properties. Viscosity at 38°C (100°F), 10^{-6} m^2/sec (Cs.) = 280-320; viscosity at 99°C (210°F), 10^{-6} m^2/sec (Cs.) = 16 min.; pour point (max.) = -9°C (15°F); flash point (min.) = 221°C (430°F).

** E. F. Houghton & Company

*** Royal Lubricants Company

NOTES: For a description of this lubricating oil for high pressure air compressors and their recommended usage, see Section II.

In addition to the products listed, many of the commercial petroleum and lubrication companies manufacture lubricating oils which meet the requirements of this specification.

MILITARY SPECIFICATION: MIL-L-45199B

LUBRICATING OIL; INTERNAL COMBUSTION ENGINE (HIGH OUTPUT DIESEL - GRADE 10)

PROPERTIES	SPEC. REQ.	CITGO* C-510	GULF** SUPER DUTY 10W	PED-3463*** SAE 10
GRAVITY, API	-	28.5	28.1	26.5-29.0
FLASH POINT, Min.	182°C (360°F)	204°C (400°F)	235°C (455°F)	182°C to 227°C (360°F to 440°F)
FIRE POINT	-	227°C (440°F)	254°C (490°F)	-
POUR POINT, Max.	-29°C (-20°F)	-32°C (-25°F)	-32°C (-25°F)	-34°C (-30°F)
STABLE POUR POINT, Max.	-29°C (-20°F)	-29°C (-20°F)	< -32°C (< -25°F)	-
VISCOSITY, 10^{-6} m^2/sec (Cs.)				
at -18°C (0°F), Max.	2,614	2,610	2,060	2,172-2,200
at 99°C (210°F), Max.	5.44-7.29	6.04	5.82	5.95-6.50
VISCOSITY INDEX	-	95	116	106-113
FOAMING PROPERTIES: Allowable Foam Immediately After 5-min. Blowing (after 10-min. settling), 10^{-6} m^3 or ml.				
(a) Sequence 1 at 24°C (75°F)	25 (0)	Passes	Passes	Passes
(b) Sequence 2 at 93°C (200°F)	125 (0)	Passes	Passes	Passes
(c) Sequence 3 at 24°C (75°F)	25 (0)	Passes	Passes	Passes
OXIDATION CHARACTERISTICS: (clr. engine test)	Pass	Passes	Passes	Passes
RING STICK, WEAR AND DEPOSITS (480 hr., "caterpillar" diesel test engine)	Pass	Passes	Passes	Passes
COMPATIBILITY: (other oils per spec.)				
CARBON RESIDUE, % Max.	-	2.8	2.82	2.15-2.18
SULFATED RESIDUE, %	-	2.3-2.6	2.64	1.8-2.6
SULFUR, %	-	0.31-0.51	0.37	0.65-0.85
PHOSPHORUS, %	-	0.015-0.025	0.02	0.63-0.74
BARIUM, %	-	0.41-0.61	0.47	-
CALCIUM, %	-	0.44-0.64	0.51	0.50-0.72
ZINC, %	-	0.015-0.025	0.02	0.66-0.78
VI IMPROVER	-	No	Yes	-
OXIDATION INHIBITOR	-	Yes	Yes	-
DETERGENT	-	Yes	Yes	-
ANTIFOAM ADDITIVE	-	-	Yes	-

MILITARY SPECIF :ATION: MIL-L-45199B

LUBRICATING OIL; INTERNAL COMBUSTION ENGINE (HIGH OUTPUT DIESEL - GRADE 10)

PROPERTIES	SPEC. REQ.	CITGO* C-510	GULF** SUPER DUTY 10W	PED-3463*** SAE 10
NEUTRALIZATION NO. 10^{-3} kg. KOH/kg (mg. KOH/g)	-	-	3.60	-
COLOR: (ASTM D 1500), Max.	-	8.0	7.5	-

* Cities Service Oil Company
** Gulf Oil Company
*** Standard Oil Company of California

NOTES: For a description and recommended usage of this grade of heavy duty engine oil, see Section II

In addition to those listed, other petroleum products which meet the requirements of this specification are:

Product Name	Manufacturer
American S-3, Motor Oil SAE 10W	American Oil Company
R-Industrial Oil No. 17-Z	American Oil Company
Ultramo Series 3	Altantic Refining Company
Conoco S-3, LC No. 42	Continental Oil Company
Essolube D-3, 10W	Humble Oil & Refining Company
Deep Rock SHD-3	International Lubricant Corporation
Phillips 66 Super HD Oil	Phillips Petroleum Company
Shell Rimula Oil 10W	Shell Oil Company
Delvac S-210	Socony Mobil Oil Company, Inc.
Ocnus HD-2410	Sun Oil Company
Ursa Oil, Super Duty SAE 10W	Texaco, Inc.

MILITARY SPECIFICATION: MIL-L-45199B

LUBRICATING OIL: INTERNAL COMBUSTION ENGINE (HIGH OUTPUT DIESEL), GRADE 30

PROPERTIES	SPEC. REQ.	CITGO* C-530	GULF** SUPER DUTY MOTOR OIL 10W, 30	PED-3464*** SAE 30
GRAVITY, API	-	26.5	26.1	26.0 to 27.8
FLASH POINT, Min.	199°C (390°F)	238°C (460°F)	257°C (495°F)	232°C (450°F)
FIRE POINT	-	266°C (510°F)	266°C (510°F)	-
POUR POINT, Max.	-18°C (0°F)	-15°C (5°F)	-18°C (0°F)	-18°C (0°F)
STABLE POUR POINT, Max.	-	-	-	-
VISCOSITY, 10^{-6} m^2/sec (Cs.) at				
-18°C (0°F) (max.)	43,570	21,700	14,100	13,000 to 14,980
99°C (210°F) (max.)	9.65 to 12.98	10.31 to 12.14	11.75	11.66 to 12.34
VISCOSITY INDEX	-	95	100	96 to 99
FOAMING PROPERTIES, Allowable Foam Immediately After 5 Min. Blowing (after 10 min. settling), 10^{-6} m^3 or ml.				
a. Sequence 1 at 24°C (75°F)	25 (0)	Passes	Passes	Passes
b. Sequence 2 at 93°C (200°F)	125 (0)	Passes	Passes	Passes
c. Sequence 3 at 24°C (75°F)	25 (0)	Passes	Passes	Passes
OXIDATION CHARACTERISTICS (clr. engine test)	Pass	Passes	Passes	Passes
RINK STICK, WEAR AND DEPOSITS (48 hr., "caterpillar" diesel test engine)	Pass	Passes	Passes	Passes
COMPATIBILITY (other oils per spec.)	Pass	Passes	Passes	Passes
CARBON RESIDUE, %, Max.	-	2.8	2.68	2.13 to 2.35
SULFATED RESIDUE, %	-	2.3 to 2.6	2.54	1.8 to 2.1
SULFUR, %	-	0.31 to 0.51	0.34	0.60 to 0.64
PHOSPHORUS, %	-	0.015 to 0.025	0.02	0.63
BARIUM, %	-	0.41 to 0.61	0.46	-
CALCIUM, %	-	0.44 to 0.64	0.50	0.50 to 0.60
ZINC, %	-	0.015 to 0.025	0.02	0.66
VI IMPROVER	-	No	Yes	-
OXIDATION INHIBITOR	-	Yes	Yes	-
DETERGENT	-	Yes	Yes	-
ANTIFOAM ADDITIVE	-	-	Yes	-
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g)			3.30	

MILITARY SPECIFICATION: MIL-L-45199B

LUBRICATING OIL: INTERNAL COMBUSTION ENGINE (HIGH OUTPUT DIESEL), GRADE 30

PROPERTIES	SPEC. REQ.	CITGO* C-530	GULF** SUPER DUTY MOTOR OIL 10W, 30	PED-3464*** SAE 30
COLOR (ASTM D 1500), Max.	-	8.0	7.5	-

* Cities Service Oil Company
** Gulf Oil Company
*** Standard Oil Company of California

NOTES: For a description and recommended usage of this grade of heavy duty engine oil, see Section II.

In addition to the products listed, most petroleum and lubricant companies produce heavy duty oils which meet the requirements of this specification. Some of these are:

Product Name	Manufacturer
American S-3, Motor Oil SAE 30	American Oil Company
R-Industrial Oil, No. 57 Z	American Oil Company
Ultramo Series 3	Atlantic Refining Company
Conoco S-3, Diesel Oil	Continental Oil Company
Posolube Series 3	Golden Bear Oil Company
Essolube D-3, SAE 30	Shell Oil Company
Phillips 66, Super HD Oil	Phillips Petroleum Company
Shell Rimula Oil, SAE 30	Shell Oil Company
Tagolene S-3	Skelly Oil Company
Delvac S-230	Socony Mobil Oil Company, Inc.
Ocnus HD 2430	Sun Oil Company
Ursa Oil S-3, SAE 30	Texaco, Inc.

LOW VAPOR PRESSURE SYNTHETIC FLUIDS

"APIEZON" HIGH VACUUM AND LUBRICATING OILS (JAMES G. BIDDLE COMPANY)

PROPERTIES	DIFFUSION PUMP OILS			LUBRICATE AND SEALING OILS	
	OIL A	OIL B	OIL C	OIL J	OIL K
ULTIMATE PRESSURE OBTAINABLE					
N/m^2	6.65×10^{-3}	1.33×10^{-4}	1.33×10^{-5}	-	-
Torr	5×10^{-5}	10^{-6}	10^{-7}	-	-
AVERAGE BOILING POINT at					
133.3 N/m^2 (1.0 torr), °C	190	220	255	-	-
(°F)	(374)	(428)	(491)	-	-
SPECIFIC GRAVITY at 20°C/15.5°C					
(68°F/60°F)	0.865	0.873	0.876	0.918	0.919
30°C/15.5°C (86°F/60°F)	0.859	0.869	0.869	0.911	0.914
DENSITY, g/ml at:					
10°C (50°F)	0.871	0.878	0.881	0.923	0.921
20°C (68°F)	0.865	0.872	0.875	0.918	0.916
30°C (86°F)	0.859	0.866	0.869	0.909	0.912
40°C (104°F)	0.852	0.859	0.863	0.903	0.904
FLASH POINT, °C (°F) Closed	210 (410)	243 (470)	246 (475)	310 (590)	341 (645)
Open	210 (410)	243 (470)	266 (510)	352 (665)	349 (660)
Fire	232 (450)	263 (505)	293 (560)	> 371 (> 700)	> 371 (> 700)
VISCOSITY, KINEMATIC,					
10^{-6} m^2/sec (Cs.) at					
20°C (68°F)	59	142	283		
40°C (104°F)	23.4	49.3	90	3,330	5,710
100°C (212°F)	4.5	7.0	10.6	107	177
VISCOSITY, DYNAMIC, 10^{-3} N sec/m^2					
(cP) at 40°C (104°F)	19.9	42.4	77.2	3,005	5,160
POUR POINT, ASTM, °C (°F)	-7 (20)	-9 (15)	-15 (5)	-1 (30)	-1 (30)
COEFFICIENT OF EXPANSION OVER					
10°C-40°C (50°F-104°F)					
per °C	0.00083	0.00080	0.00080	0.00083	0.00070
per °F	0.00046	0.00044	0.00044	0.00046	0.00039
AVERAGE MOLECULAR WEIGHT	354	420	479	1,130	1,355
REFRACTIVE INDEX at 20°C					
(68°F) (ASTM D 1807 62T					
Sodium D line)	1.4780	1.4815	1.4830		
THERMAL CONDUCTIVITY Btu in					
ft^2/h, °F	0.91	0.91	0.96	1.16	1.17
w/m, °C	0.132	0.132	0.139	0.167	0.169
SPECIFIC HEAT at 25°C (77°F)					
cal/g	0.46	0.49	0.46	0.48	0.46
Joule/g	1.9	2.0	1.9	2.0	1.9

NOTES: 1. The fluids combine good lubricating properties with low vapor pressure, and are intended for lubrication of all moveable parts in a vacuum system. They also have good chemical stability.

2. "Apiezon" Oils A, B, and C are primarily vacuum diffusion pump oils, while Oils J and K are lubricating and sealing oils for rotating gland seals and similar equipment. Oil J is moderately viscous with a low vapor pressure, and K is exceedingly viscous and has even lower vapor pressure than J.

BALL BROTHERS RESEARCH CORPORATION

PROPERTIES	VAC KOTE OIL 36218	VAC KOTE OIL 36233	VAC KOTE OIL 36234
MILITARY SPECIFICATION	None	None	None
COMPOSITION: Base Oil	Synthetic	Hydrocarbon	Synthetic
Additives	-	-	-
FLASH POINT	> 260°C (> 500°F)	> 260°C (> 500°F)	288°C (550°F)
FIRE POINT	> 260°C (> 500°F)	> 260°C (> 500°F)	> 288°C (> 550°F)
POUR POINT	-40°C (-40°F)	-9°C (45°F)	-51°C (-60°F)
USABLE TEMPERATURE RANGE: Low	-40°C (-40°F)	-7°C (20°F)	-48°C (-55°F)
High	232°C (450°F)	93°C (200°F)	121°C (250°F)
EVAPORATION; % Wt. Loss, 28 hr. at 154°C (310°F)	1.8	0.90	0.40
VISCOSITY: 10^{-6} m^2/sec (Cs.); at 99°C (210°F)	10	10	9
at 38°C (100°F)	78	100	56
VISCOSITY INDEX	110	93	129
SHELL FOUR-BALL WEAR TEST; at 100°C (212°F) 90 min., 600 rpm, 98.07 N (10 kg.); Average Scar Dia.: mm.	0.207	0.483	0.266
OXIDATION STABILITY: (Bomb) at 99°C (210°F) Pressure Drop at 100 hr., N/m^2 (psi)	0 (0)	28,960 N/m^2 (4.2 psi)	4,137 N/m^2 (0.6 psi)
Viscosity Change at 38°C (100°F); 10^{-6} m^2/sec (Cs.)	0	+3.8	+0.2
Acid Number Change: 10^{-3} kg. KOH/kg (mg. KOH/g)	0	+0.65	+0.72
SURFACE TENSION: Dynes/cm, 23°C (73°F)	23	34	28.5
COMPATIBILITY WITH METALS: (48 hr. in 0.1 at 64°C (148°F) 440 C & 52100 Steel, Brass & Copper	No change	No change	No change
Silver, Aluminum (2024T3), & Titanium (6Al-4V)	No change	No change	No change
COMPATIBILITY WITH; Rubber	Synthetic	Satisfactory	Synthetic
Jet and Rocket Fuel	-	-	-
LOX	Satisfactory	-	-
FLUID PROPERTIES			
Foam Resistant	Yes	-	-
Wear Resistant (EP)	Yes	Yes	Yes
Corrosion Inhibiting	-	Yes	Yes
Water Resistant	Yes	-	-
Good Storage Stability	Yes	Yes	Yes

NOTES: Vac Kote Oil 36218 is a chemically and thermally stable oil for air vacuum and space lubrication. Typical uses are for low and high speed bearing; journal, ball or roller, sliding surfaces, gears and electrical equipment.

Vac Kote Oils 36233 and 36234 are extreme pressure oils for air, vacuum and space lubrications. Typical applications are similar to Vac Kote Oil 36218.

LOW VISCOSITY TURBINE OIL

PETROLEUM BASE, (Bray Oil Company)

PROPERTIES	DOUGLAS AIRCRAFT SPEC. DPM-352	BRAYCO 450
GRAVITY, °API	28.0 - 30.0	28.6
FLASH POINT, COC, Minimum	154°C (310°F)	166°C (330°F)
POUR POINT, Maximum	-40°C (-40°F)	-43°C (-45°F)
VISCOSITY, 10^{-6} m^2/sec (Cs.)		
at -18°C (0°F)	1,195 - 1,415	1,275
at 38°C (100°F)	29.7 - 30.8	30.4
at 99°C (210°F)	5.17 - 5.29	5.29
CARBON RESIDUE, CONRADSON, % Wt.	0.55 - 0.70	0.65
ACIDITY, 10^{-3} kg. KOH/kg (mg. KOH/g)	Alkaline	0.10 Basic
VISCOSITY INDEX: Minimum	110	113
CORRISION AND OXIDATION STABILITY, 76°C (168 hr.) at 121°C (250°F), Wt. Change, 10^{-10} kg/m^2 (mg/cm^2), Maximum		
Steel	± 0.2	0.0
Copper	± 0.2	0.0
Aluminum Alloy	± 0.2	0.0
Magnesium Alloy	± 0.2	0.0
Cadmium Alloy	± 0.2	0.0
Change in Viscosity at 38°C (100°F), %	-5 to +20	4.5
Change in Neutralization No., 10^{-3} kg. KOH/kg (mg. KOH/g), Maximum	0.2	0.10
Gumming and Insolubles	None	None

NOTE: Brayco 450 is a low viscosity oil for high speed mechanisms with superior lubricant properties to most spindle and turbine oils. It has a low pour point and good high temperature properties as well as good oxidation stability and rust protection properties. It contains additives to attain very good lubricity and added film strength or load carrying ability. This oil is rated as a good heavy duty lubricant.

Recommended uses: High speed mechanisms, expansion turbines or jet turbo engines, hydraulic torque converters, fluid couplings, and planetary gears.

ELECTRICAL INSULATING OIL, PETROLEUM BASE (BRAY OIL COMPANY)

PROPERTIES	G.E. SPEC. 46A100318	BRAYCO 707
GRAVITY, API	30-34	31.4
COMPOSITION, Base Oil	-	Highly refined petroleum
Additives	-	Oxidation and sludging
FLASH POINT, COC, Minimum	132°C (270°F)	135°C (275°F)
POUR POINT, Maximum	-65°C (-85°F)	< -65°C (< -85°F)
USABLE TEMPERATURE RANGE,	-	-54°C to 121°C (-65° to 250°F)
VISCOSITY, 10^{-6} m^2/sec (Cs.) at 38°C (100°F), Minimum	6.8	7.08
at -54°C (-65°F), Maximum	12,000	11,800
DIELECTRIC STRENGTH, kv., Minimum	> 35	> 35
WATER AND SEDIMENT, % Wt.	0	0
CORROSION AND OXIDATION STABILITY, Air at 121°C (250°F), 168 hr. Metals %, Wt. Change, 10^{-10} kg/m^2 (mg/cm^2)		
Copper, Maximum	± 0.6	-0.01
Al. Alloy, Maximum	± 0.2	0.00
Magnesium Alloy, Maximum	± 0.2	0.00
Steel, Maximum	± 0.2	0.00
Cadmium, Maximum	± 0.2	0.00
Change in Neutralization No., Maximum	0.2	0.01
Change in Viscosity, at 38°C (100°F), %	-5 to +20	+5.0

NOTES: Brayco 707 meets the requirements of General Electric Spec. 46A100318.

RECOMMENDED USES: Transformers, circuit breakers, applications encountering high voltage gradients.

HIGH TEMPERATURE SYNTHETIC FLUIDS

PERFLUOROCARBON FLUIDS (E.I. du Pont de Nemours and Company)

PROPERTIES	HYDRAULIC FLUID PR-143*	GAS TURBINE OIL PR-143*
USABLE TEMPERATURE RANGE	-46°C to 371°C (-50°F to 700°F)	-46°C to 371°C (-50°F to 700°F)
POUR POINT	-43°C (-45°F)	-29°C (-20°F)
INCIPIENT DECOMPOSITION TEMPERATURE	417°C (782°F)	417°C (782°F)
THERMAL DECOMPOSITION RATE, %/Day		
at 343°C (650°F)	0.01	0.01
at 399°C (750°F)	~ 1.30	~ 1.30
AUTO. IGNITION TEMPERATURE	704°C (> 1300°F)	704°C (> 1300°F)
HOT MANIFOLD TEST (flash or fire at 732°C (1350°F)	None	None
HIGH PRESSURE SPRAY IGNITION (flash or ignite)	None	None
VISCOSITY, 10^{-6} m^2/sec (Cs.)		
at -29°C (-20°F)	32,000	-
at -18°C (0°F)	7,400	38,600
at 38°C (100°F)	95	300
at 100°C (210°F)	11	28
at 204°C (400°F)	1.9	4.1
VISCOSITY INDEX	109.0	119.0
ASTM SLOPE	0.68	0.59
VOLATILITY, % Wt. Loss, 6.5 hr. at 204°C (400°F)	15.0	Negl.
6.5 hr. at 260°C (500°F)	53.0	2.0
DENSITY, kg/10^{-3} m^3 (g/ml)		
at 24°C (75°F)	1.90	1.90
at 93°C (200°F)	1.77	1.77
at 149°C (300°F)	1.67	1.67
at 204°C (400°F)	1.57	1.57
FOAMING (5.0 min. blowing, 10.0 min. settling)	Negl.	Negl.
HYDROLYTIC STABILITY, 48 hr. at 93°C (200°F)		
Copper Strip, Weight Change, %	0.00	0.00
Copper Appearance	Light tarnish	Light tarnish
Viscosity Change at 38°C (100°F), %	+0.4	+0.4
Neutralization Number, 10^{-3} kg. KOH/kg (mg. KOH/g)	< 0.01	< 0.01
Insolubles, % Wt.	0.00	0.00
Color, ASTM, D-1500	≤ 0.05	0.5
RADIATION RESISTANCE (dosage = 10^7 rads. of thermal neutrons and γ-rays) Viscosity Change at 38°C (100°F), %	-7.8	-7.8
Neutralization Number, 10^{-3} kg. KOH/kg (mg. KOH/g)	2.9	2.9
FOUR-BALL WEAR TEST (1.0 hr. at 600 rpm) 52100 Steel Balls in Air		
75°C (167°F), 98.1 N (10 kg.) Load; Scar Dia. 10^{-3} m.	-	0.26
75°C (167°F), 372.4 N (40 kg.) Load; Scar Dia. 10^{-3} m.	-	1.02
204°C (400°F), 98.1 N (10 kg.) Load; Scar Dia. 10^{-3} m.	-	0.36
204°C (400°F), 372.4 N (40 kg.) Load; Scar Dia. 10^{-3} m.	-	1.43
M-10 Steel Balls in Air		
371°C (700°F), 98.1 N (10 kg.) Load; Scar Dia. 10^{-3} m.	-	0.52
371°C (700°F), 372.4 N (40 kg.) Load, Scar Dia. 10^{-3} m.	-	0.70

* Property values given are typical, as the PR-143 class of fluids can be altered to fit specific requirements.

NOTE: PR-143 synthetic fluids are colorless and odorless; they have very good thermal and chemical stability, and cause little effect on swelling of elastomers. Lubrication with these fluids is obtained up to 371°C (700°F) with varying speed and load conditions.

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"FOMBLIN" FLUORINATED FLUIDS (MONTECATINI EDISON S.p.A.)

PROPERTIES	Y01	Y04	Y06	Y25	YU	YR
APPEARANCE	Clear and Colorless, All Grades					
DISTILLATION RANGE, °C 90% mm., 0.3-0.4 mm. Hg. °F	230-374 (9.5 mm. hg.)	176-410	-	374-554	-	518
POUR POINT	< -73 (< -100)	< -68 (< -90)	< -46 (< -50)	< -34 (< -30)	< -29 (< -20)	< -23 (< -10)
VAPOR PRESSURE, mm. Hg. at 149°C (300°F)	40	3.5	1.3	0.06	-	0.0005
AVERAGE COEFFICIENT OF THERMAL EXPANSION						
-1°C to 121°C x 10^4/°C	11.2	10.8	10.4	9.4	9.4	9.4
(30°F to 250°F) x 10^4/°F	6.2	6.0	5.8	5.2	5.2	5.2
VISCOSITY, 10^{-6} m^2/sec (Cs.)						
at -18°C (0°F)	100	600	2,000	11,000	12,000	70,000
at 38°C (100°F)	4.5	16	28	90	162	516
at 99°C (210°F)	1.4	3.2	4.0	9.4	18.6	41
VISCOSITY INDEX	-	52	58	106	130	134
SPECIFIC GRAVITY, 25°/25°C (77°/77°F)	1.85	1.87	1.88	1.90	1.90	1.91
DENSITY, 25°C (77°F), kg/m^3 (lb/gal)	1,848 (15.4)	1,872 (15.6)	1,884 (15.7)	1,896 (15.8)	1,896 (15.8)	1,908 (15.9)
AUTOIGNITION TEMPERATURE	None	None	None	None	None	None
FLASH POINT	None	None	None	None	None	None
FIRE POINT	None	None	None	None	None	None
REFRACTIVE INDEX, n_D^{25}	1.289	1.296	1.296	1.300	1.299	1.304
SPECIFIC HEAT, Joule/kg (Btu/lb) at 38°C (100°F)	558 (0.24) for All Grades					
THERMAL CONDUCTIVITY, 16°-93°C (60°-200°F), Watt/m°C (Btu-ft/hr ft^2°F)	0.000492 (0.041) for All Grades					
ACID NUMBER	0.00 for All Grades					

"FOMBLIN" FLUORINATED FLUIDS (MONTECATINI EDISON S.p.A.)

PROPERTIES	Y01	Y04	Y06	Y25	YU	YR
SURFACE TENSION at 25°C (77°F), Dynes/cm	18	19	19	20	20	21
DIELECTRIC STRENGTH, 0.254 cm. (0.1 in. gap)			Greater Than 30 kv.			
VOLATILITY and Weight Loss 22 hr. at 149°C (300°F)	100	60	40	7	10	1

NOTES: 1. General properties: The Fomblin fluids are linear perfluoropolyethers and are available in several grades with different average molecular weights. These fluids possess outstanding resistance to oxidation and chemical attack, have excellent thermal stability, a wide liquid-temperature range, and good lubricating capability.

They are suggested as lubricants and sealing compounds for applications requiring exceptional thermal resistance, or resistance to oxidation and chemical attack.

2. Lubricity: The Fomblin fluids are good lubricants, particularly under boundary and E.P. conditions. For example, with Fomblin Y25 in the 4-ball wear test with steel on steel for 2 hr. at 40 kg. and 1,200 rpm, the average wear scar diameter was only 0.86 mm. In the 4-ball E.P. test for 1 min. at 1,500 rpm the maximum load before seizure was 50 kg.

3. Chemical stability: The Fomblin fluids are stable in contact with fuels, strong acids and bases, chlorine, fluorine, bromine, oxidizing agents, water, and steam. The Fomblin Y01, Y04, Y25 fluids will not react with pure oxygen at 249°C (480°F) at pressures up to 11.7×10^6 N/m^2 (1,700 psi).

The Fomblin YR and YU fluids will not react with pure oxygen at 249°C (480°F) at pressures up to 8.6×10^6 N/m^2 (1,250 psi).

The Fomblin fluids are decomposed by halogenated Lewis acids such as $AlCl_3$, SbF_5 and CoF_3 at temperatures above 100°C (212°F).

The Fomblin fluids (in common with other highly fluorinated fluids) may react violently with aluminum and magnesium and their alloys under conditions where fresh, active metal surfaces may be created; such as under high rates of shear or high bearing loads. These conditions could occur during machining and drilling of parts; or during the operation of a loaded bearing; or movement of a threaded connector.

4. Compatability with plastics and elastomers: The Fomblin fluids do not affect most commercially available plastic and elastomeric materials. For example, elastomers such as nitrile, butyl, fluorosilicone, Viton are unchanged after soaking 1 month in Fomblin Y04 fluid at 70°C (158°F). Most plastics (polyamides, polyacetals, PTFE, etc.) may be used in contact with the fluids up to the top temperature limitation of the plastic material itself.

5. These oils are used in special greases, see Braycote 631A, Bray Oil Company.

FLUOROCARBON LIQUIDS: FLUORINATED ETHER FLUIDS

HYDRAULIC AND INSTRUMENT FLUIDS; E. I. du PONT de NEMOURS & COMPANY)

PROPERTIES	FREON E1	FREON E2	FREON E3	FREON E4	FREON E5
BOILING POINT	39°C (102°F)	101°C (214°F)	152°C (306°F)	193°C (380°F)	218°C (424°F)
FLASH POINT	None	None	None	None	None
POUR POINT	-154°C (-246°F)	-122°C (-188°F)	-115°C (-175°F)	-95°C (-139°F)	-72°C (-98°F)
FLAMMABILITY	Nonflam.	Nonflam.	Nonflam.	Nonflam.	Nonflam.
VISCOSITY, 10^{-6} m^2/sec (Cs.) at -54°C (-65°F)	-	5.0	21.6	140*	-
at 25°C (77°F)	0.33	0.61	1.2	2.3	3.9
SPECIFIC HEAT OF LIQUID at 25°C (77°F) Joule/kg°C (cal/g/°C)	-	1,021 (0.244)	1,017 (0.243)		-
DENSITY, 10^{-3} Kg/m^3 (g/cm) at -54°C (-65°F)*	1.752	1.841	1.882	1.909	1.924
25°C (77°F)	1.538	1.659	1.723	1.765	1.796
VAPOR PRESSURE N/m^2 (mm. Hg) at 25°C (77°F)	57,300 (430)	3,870 (29)	320 (2.4)	-	-
LIQUID THERMAL CONDUCTIVITY, Watt/m°C (Btu . ft/hr ft^2 °F) at 25°C (77°F)		0.0778 (0.045)	0.0713 (0.0412)		-
DIELECTRIC STRENGTH KV_{rms}/0.00254 m. (KV_{rms}/0.10 in.)		34.6	39.5	44.5	49.5
DIELECTRIC CONSTANT (100 cps)		2.76	2.58		-
PERCENT COMPRESSIBILITY at 25°C (77°F) 101 x 10^5 N/m^2 (100 ATMS)	2.38	1.81	1.55	1.42	1.34
505 x 10^5 N/m^2 (500 ATMS)	8.20	6.48	5.64	5.18	4.85
1010 x N^5/m^2 (1,000 ATMS)	12.13	9.93	8.81	8.14	7.76
COMPATIBILITY: Plastics	Yes	Yes	Yes	Yes	Yes
Elastomers	Yes	Yes	Yes	Yes	Yes

* Extrapolated Data

NOTES: These fluids are part of a series of Freon E, homologous fluorinated ethers, low volatility fluids which cover a wide range of properties. All are usable at very high and low temperatures, nonflammable, have a low order of acute toxicity, excellent electrical properties, and have good heat transfer properties.

Some of the recommended usages are: liquids for extreme environment conditions, as hydraulic and instrument fluids, heat transfer media, and as dielectric-coolants.

GYRO LUBRICANTS[2]
KENDALL REFINING COMPANY

PROPERTIES	SRG-40	SRG-60	KG-80	SRG-100
MILITARY SPECIFICATION	-	-	MIL-L-83176	-
GRAVITY: API	30.8	30.9	29.6	30.3
COMPOSITION: Base Oil	Mineral Oil	Mineral Oil	Mineral Oil	Mineral Oil
Additives: Antioxidant, %	0.5	0.5	0.5	0.5
Tri-cresyl-phosphate, %	1.0	1.0	1.0	1.0
VISCOSITY: 10^{-6} m^2/sec. (Cs.) at 38°C	27.4	77.6	164	257
(100°F) at 99°C (210°F)	4.64	9.44	15.3	22.4
VISCOSITY INDEX	101	106	101	110
POUR POINT	-26°C (-15°F)	-12°C (10°F)	-9°C (15°F)	-9°C (15°F)
FLASH POINT	188°C (370°F)	232°C (450°F)	274°C (525°F)	288°C (500°F)
FIRE POINT	202°C (395°F)	277°C (530°F)	324°C (615°F)	332°C (630°F)
VAPOR PRESSURE/TEMPERATURE (1)				
133.3 N/m^2 (1.0 torr)	217°C (422°F)	263°C (505°F)	298°C (568°F)	323°C (613°F)
13.3 N/m^2 (0.10 torr)	181°C (358°F)	226°C (439°F)	260°C (500°F)	283°C (541°F)
1.33 N/m^2 (0.010 torr)	155°C (311°F)	198°C (388°F)	232°C (450°F)	253°C (487°F)
0.133 N/m^2 (0.001 torr)	136°C (277°F)	178°C (352°F)	212°C (414°F)	233°C (451°F)

NOTES: 1. These vapor pressure-temperature relations are based on the ASTM distillation 50% boiling point. The Meyers vapor pressure-temperature correlation was used to convert to other pressures.

2. In addition to these super refined fluids, these instrument lubricants are available in a grease. These greases are designated by the lubricant name and the term "grease" as a suffix (i.e., SRG-60 Grease, or KG-80 Grease).

PERFLUORINATED LUBRICANTS OR HYDRAULIC FLUIDS:

NONFLAMMABLE AND CHEMICALLY INERT (Bray Oil Company)

PROPERTIES	BRAYCO 810	BRAYCO 811	BRAYCO 812	BRAYCO 813
DENSITY, 16°C (60°F)	1.913	1.888	1.910	1.924
COLOR, Saybolt	+30	+30	+30	+30
POUR POINT	-26°C (-15°F)	-48°C (-55°F)	-29°C (-20°F)	-18°C (0°F)
FLASH/FIRE, Point	← Nonflammable →			
VISCOSITY, 10^{-6} m^2/sec (Cs.) at				
204°C (400°F) (extrapolated)	2.98	0.96	2.20	5.00
99°C (210°F)	16.1	3.29	10.9	35.5
38°C (100°F)	153	18.7	96.3	424
-18°C (0°F)	16,800	625	8,800	75,000
-40°C (-40°F)	-	9,400	-	-
VISCOSITY INDEX	119	11	106	133
THERMAL COEFFICIENT OF EXPANSION				
25°C to 121°C	0.00099	0.00099	0.00097	0.00101
(77°F to 250°F)	0.00055	0.00055	0.00054	0.00056
ACID NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g)	0.0	0.0	0.0	0.0
CORROSION AND OXIDATION STABILITY, 204°C (400°F)/72 hr., Weight Change (mg/cm^2)				
Copper	0.00	+0.01	+0.02	+0.04
Aluminum Alloy	+0.03	+0.05	+0.02	+0.01
Magnesium Alloy	+0.03	+0.05	-0.02	0.02
Steel	+0.03	+0.06	0.00	+0.02
Silver	+0.03	+0.06	-0.02	0.00
Appearance Pitting, Etching, Corrosion	None	None	None	None
Viscosity Change at 38°C (100°F), %	+2.62	+2.25	+0.06	+0.24
Acid Number Increase	0.0	0.0	0.0	0.0
DISTILLATION RANGE, °C/at 0.4 x 10^{-3} m.	-	80 to 210	190 to 290	> 270
(°F/at 0.4 mm.)	-	(176 to 410)	(374-554)	(> 518)
EVAPORATION LOSS, 149°C (300°F)/ 22 hr., %	6	52	2	Nil
204°C (400°F)/6-1/2 hr., %	11.40	81.0	7.12	0.12
REFRACTIVE INDEX, n_D^{20}	1.300	1.296	1.300	1.304
SURFACE TENSION, Dyne/cm at 20°C	20	19	20	21
THERMAL CONDUCTIVITY, Watt/m °C at 38°C	-	-	0.0709	-
(Btu/hr (ft^2) (°F/ft) at 100°F))	-	-	(0.041)	-
SPECIFIC HEAT, Joule/kg/°C	557.9	557.9	557.9	557.9
(Btu/lb/°F)	(0.24)	(0.24)	(0.24)	(0.24)
DIELECTRIC STRENGTH (kv.)	35+	35+	35+	35+
DIELECTRIC CONSTANT AT 50 Hz	2.15	2.15	2.15	2.15
1,000 Hz	2.17	2.17	2.17	2.17

PERFLUORINATED LUBRICANTS OR HYDRAULIC FLUIDS:

NONFLAMMABLE AND CHEMICALLY INERT (Bray Oil Company)

PROPERTIES	BRAYCO 810	BRAYCO 811	BRAYCO 812	BRAYCO 813
VOLUME RESISTIVITY (ohm-cm.), at 25°C (77°F)	$> 10^{15}$	$> 10^{15}$	$> 10^{15}$	$> 10^{15}$
DISSIPATION FACTOR at 25°C (77°F), %	$< 10^{-4}$	$< 10^{-4}$	$< 10^{-4}$	$< 10^{-4}$
PARTICLE CONTAMINATION, Number of Particles/10^{-4} m^3 (particles/100 ml) Particle Size Range, 10^{-6} m. (microns)				
5-15	750	750	750	750
15-25	200	200	200	200
25-50	35	35	35	35
50-100	18	18	18	18
100+	2	2	2	2

NOTES:

1. Description: BRAYCO 810-13 oils are linear perfluoroalkyl polyethers. BRAYCO 810 is the total polymer and 811-13 are distillate fractions of increasing molecular weight. They are colorless and odorless, are nonflammable, and are generally chemically inert. They are thermally stable, either alone or in the presence of oxygen, have low volatility and have no tendency to form deposits. Excellent lubricating properties, good dielectric properties, excellent shear stability, and a very low order of acute toxicity characterize these unusual fluids.

2. Compatibility: BRAYCO 810-13 oils are insoluble or at most sparingly soluble in most organic solvents and materials other than fluorinated solvents. They are compatible at normal operating temperatures with conventional metals, plastics and elastomers.

3. Limitations: BRAYCO 810-3 oils are adversely affected by Friedel-Crafts catalysts such as $AlCl_3$ at elevated temperatures. Rubbing surfaces of aluminum or magnesium under certain conditions may react. Such systems should be thoroughly evaluated. The fluids should be evaluated for corrosivity with materials of construction when design temperatures are above 204°C (400°F).

4. Uses: BRAYCO 810-813 oils are designed for use as a lubricant or hydraulic fluids where they may be exposed to fuels and oxidizers or to systems operating up to temperatures of 316°C (600°F). They have been used as damping fluids, flotation fluids, lubricants for electrical contacts, lubricants in corrosive service, heat transfer media, and dielectric fluids. Their wide range of viscosities enable their use for most applications either as provided or by blending.

5. Specifications: BRAYCO 810-3 oils are proprietary products manufactured by Montecatini Edison S.p.A. under the trademark Fomblin Fluorinated Fluids.

SYNTHETIC HIGH TEMPERATURE OILS (LOW VOLATILITY, ESTER BASE LUBRICATING OIL)

PROPERTIES	ANDEROL[a/] L-826	STAUFFER[b/] 3664	BRAYCO[c/] NPT 5	BRAYCO[c/] 830
FLASH POINT	260°C (500°F)	260°C (500°F)	221°C (430°F)	260°C (500°F)
FIRE POINT	285°C (545°F)	299°C (570°F)	-	302°C (575°F)
AUTO. IGNITION TEMPERATURE	443°C (830°F)	427°C (800°F)	396°C (745°F)	427°C (800°F)
POUR POINT	-62°C (-80°F)	-37°C (-35°F)	-62°C (-80°F)	-51°C (-60°F)
USABLE TEMPERATURE RANGE	-40°C to 260°C (-40°F to 500°F)	- -	-40°C to 260°C (-40°F to 500°F)	-34°C to 260°C (-30°F to 500°F)
EVAPORATION, 6-1/2 hr. at 204°C (400°F), % Wt. Loss	3.9	4.0	5.05	2.2
VISCOSITY, 10^{-6} m^2/sec (Cs.)				
at 204°C (400°F)	1.7	-	-	1.32
at 99°C (210°F)	6.7	4.7	5.15	4.94
at 38°C (100°F)	37.9	22.9	26.17	24.3
at -18°C (0°F)	1,400	-	-	558
	(13,000 at -33°F)	-	(57,200 at -65°F)	(5489 at -40°F)
VISCOSITY INDEX	136	140	136	143
SPECIFIC GRAVITY	0.90	0.948	0.969	0.947
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg/KOH/g)	0.2	0.02	0.04	-
OXIDATION CORROSION, 72 hr. at 175°C (347°F), Wt. Loss				
10^{-10} kg/m^2 (mg/cm^2) Steel	0.02	None	-0.016	+0.01
Silver	0.03	None	-0.008	-0.03
Aluminum	0.05	None	-0.032	+0.01
Magnesium	0.05	None	-0.016	0.00
Copper	0.12	None	-0.072	-0.11
Viscosity Change at 100°F, %	-	+7	+3.84	+2.1
Neutralization Number Change, 10^{-3} kg. KOH/kg (mg/KOH/g)	-	+0.19	0.31	0.05
Evaporation Loss, %	-	-1.0	-	-
COMPATIBILITY WITH OTHER TURBINE FLUIDS	Passes	Passes	Passes	Passes
FOAMING PROPERTIES (after 5.0 min. 10^{-6} m^3 (ml.), aeration)	Passes	Passes	-	None
TOXICITY	-	Slight	-	-
SYNTHETIC ELASTOMER SWELLING (1 week at 70°C (158°F)				
"H" Stock, ° Change (vol.)	-	+10	-	-
Viton A, % Change (vol.)	-	+5	-	-
RYDER GEAR TEST, lb-in	3,000	2,500	2,800	-

SYNTHETIC HIGH TEMPERATURE OILS (LOW VOLATILITY, ESTER BASE LUBRICATING OIL)

PROPERTIES	ANDEROL[a/] L-826	STAUFFER[b/] 3664	BRAYCO[c/] NPT 5	BRAYCO[c/] 830
SHELL Four-Ball Wear Test, 9.81 N (1 kg.) Load, 1 hr. at 70°C (158°F)	-	0.23	-	-
Scar Dia., 10^{-3} m., 372.4 N (40 kg.) Load, 1 hr. at 70°C (158°F)	-	0.58	-	-
9.81 N (1 kg.) Load, 2 hr. at 75°C (167°F), 600 rpm	-	-	0.324	-
37.2 N (4 kg.) Load, 2 hr. at 75°C (167°F), 600 rpm	-	-	0.518	-
98.1 N (10 kg.) Load, 2 hr. at 75°C (167°F), 600 rpm	-	-	0.686	-
491 N (50 kg.) Load, 2 hr. at 75°C (167°F), 600 rpm	-	-	0.805	-

a/ Lehigh Chemical Company: A medium-heavy diester oil, with excellent thermal stability and load-carrying ability over the temperature range of -40°C to 260°C (-40°F to 500°F). Compatible with other turbine fluids, recommended for high temperature instruments, machine tools, gas turbines, hydraulic systems, etc.

b/ Stauffer Chemical Company: A synthetic polyester base stock prepared for use in high temperature gas turbine engines. It has good heat transfer, excellent antiwear and E.P. lubricity, non-corrosive, is shear stable, and has a wide temperature range. Toxicity is low with good hygienic practices.

c/ Bray Oil Company: A light, intermediate viscosity, ester base lubricating oil of low volatility. It is shear stable, oxidation resistant, has high load-carrying ability, and a wide temperature range, -40°C to 260°C (-40°F to 500°F). Recommended for fine clearance uses, gear boxes, hydraulic systems, etc. It may adversely affect paints and elastomers.

CHLOROFLUOROCARBON LUBRICANTS (Halocarbon Products Corporation)

PROPERTIES	4-11E*	11-14E	11-21E	13-21E	10-25E	14-25E
DENSITY, 10^3 kg/m^3 (g/cc)						
at 38°C (100°F)	1.85	1.88	1.90	1.92	1.95	1.90
at 71°C (160°F)	1.80	1.83	1.85	1.87	1.90	1.94
at 99°C (210°F)	1.75	1.79	1.81	1.83	1.85	1.88
POUR POINT,						
°C	-79	-54	-18	-12	2	18
(°F)	(-110)	(-65)	(0)	(10)	(35)	(65)
CLOUD POINT,						
°C	< -79	< -79	-46	-15	19	25
(°F)	(< -110)	(< -110)	(-50)	(5)	(66)	(77)
ATMOSPHERIC BOILING POINT,						
°C	-	-	260	260	260	260
(°F)	(430)	(460)	(560)	(500)	(500)	(500)
VISCOSITY, 10^{-6} m^2/sec (Cs.)						
-54°C (-65°F)	8,000	-	-	-	-	-
38°C (110°F)	4.5	6.5	34	56	320	1,100
71°C (160°F)	2.0	2.5	8.0	12	37	77
99°C (210°F)	1.3	1.5	3.8	4.9	12	20
WEAR TEST, SHELL FOUR-BALL 600 rpm, 2 hr. at 75°C (167°F) (steel-on-steel), Average Wear Spot Dia., mm.:						
Load, 1.0 kg.	0.224	0.196	0.210	0.189	0.175	0.182
10 kg.	0.707	0.630	0.693	0.658	0.693	0.623
MEAN HERTZ LOAD, kg.	102.0	102.6	100.8	101.3	107.4	103.7

COMPATIBILITY DATA:

Temp. °C	(°F)	Oxidizer	Time Hours	Ratio, Oxidizer to Oil 8:1 4:1 2:1 1:4 1:99	Color Initial	Color Final	Pressure
21	(70)	H_2O_2	24	No reaction at any ratio	Clear	Clear	Ambient
71	(160)	H_2O_2	24	No reaction at any ratio	Clear	Clear	Ambient
-184	(-300)	LOX	24	No reaction at (1:1) ratio (only ratio tested for LOX)	Clear	Clear	Ambient

SHOCK SENSITIVITY DATA[a/]

Oxidizer	Ratio, Oxidizer to Oil 8:1	4:1	2:1	1:1	Treatment Temperature °C	(°F)	Test Temperature[b/] °C	(°F)
H_2O_2	None	None	None	-	71	(160)	21	(70)
H_2O_2	None	None	None	-	21	(70)	21	(70)
LOX	-	-	-	None	-184	(-300)	-184	(-300)

* The suffix E designates an oxygen-compatible rust-inhibited oil. However, the rust inhibitor system while it passes the ASTM turbine oil specification D-665 is not as effective as petroleum lubricant inhibitor systems. These oils are also available without the inhibitor in which case the suffix E is dropped.

a/ Tests run on a Picatinny Arsenal type impact tester.

b/ Mixture of halocarbon oil and 90% H_2O_2 held at constant temperature for 24 hr. prior to test.

CHLOROFLUOROCARBON LUBRICANTS (Halocarbon Products Corporation)

PROPERTIES	4-11E*	11-14E	11-21E	13-21E	10-25E	14-25E

NOTES: 1. Maximum safe operating temperature is 260°C (500°F), short-term temperature up to 288°C (550°F).

2. These halocarbon oils may be used with most elastomers and solvent-resistant plastics at room temperatures. For elevated temperatures it is recommended that tests be conducted at anticipated temperatures and pressure.

3. These oils are noncorrosive toward metals up to 177°C (350°F), except for copper and some of its alloys which discolor at 49°C (120°F). These oils should not be used for aluminum thread applications or where high shear stresses are present as detonation may result.

4. The lubricity properties of these oils are at least equivalent to petroleum oils.

PERFLUOROALKYLPOLYETHER FLUIDS (E. I. du Pont de Nemours & Company)

PROPERTIES	KRYTOX® 143AZ	KRYTOX® 143AA	KRYTOX® 143AY	KRYTOX® 143AB
DENSITY, kg/m^3 (lb/gal) at 24°C (75°F)	1,860 (15.5)	1,884 (15.7)	1,884 (15.7)	1,896 (15.8)
POUR POINT	-57°C (-70°F)	-46°C (-50°F)	-46°C (-50°F)	-43°C (-45°F)
FLASH AND FIRE POINT	Products are Nonflammable			
VISCOSITY, 10^{-6} m^2/sec (Cs.)				
at -32°C (-25°F)	2,500	9,500	21,000	46,000
-18°C (0°F)	500	1,800	3,500	6,900
38°C (100°F)	18	36	55	85
99°C (210°F)	3.3	5.4	7.6	10.3
204°C (400°F)	0.8	1.1	1.4	1.8
VISCOSITY INDEX	23	90	104	113
ASTM SLOPE	0.844	0.770	0.720	0.686
THERMAL COEFFICIENT OF EXPANSION				
Vol/Vol -°F, Average from 77 to 210°F (x 10^4)	6.1	5.8	-	5.6
Vol/Vol -°C, Average from 25 to 99°C (x 10^4)	11.0	10.4	-	10.1
APPROXIMATE BOILING RANGE at				
0.8 mm. Hg, °F	289 to 365	365 to 410	410 to 441	441 to 484
at 0.8 mm. Hg, °C	143 to 185	185 to 210	210 to 227	227 to 251
VOLATILITY, Weight % Loss, 6.5 hr.				
at 149°C (300°F)	19	2	-	-
at 204°C (400°F)	83	26	6	5
at 260°C (500°F)	-	93	64	27
THERMAL DECOMPOSITION POINT				
Different Thermal Analysis	471°C (880°F)	471°C (880°F)	471°C (880°F)	471°C (880°F)
Isotheniscope	354°C (670°F)	354°C (670°F)	354°C (670°F)	354°C (670°F)
VAPOR PRESSURE, mm. of Hg.				
at 149°C (300°F)	2.2	0.4	-	- 0.3
at 204°C (400°F)	23.5	4.8	-	2.5
at 260°C (500°F)	145.0	32.0	-	10.3
at 316°C (600°F)	600.0	157.0	-	52.5
at 371°C (700°F)	-	625.0	-	295.0
FOAMING PROPERTIES (Test Method ASTM D-892), 10^{-6} m^3 (ml.) Foam After 5-Min. Blowing				
a. Sequence I, 24°C (75°F)	10	10	5	5
b. Sequence II, 93°C (206°F)	0	0	0	0
c. Sequence III, 24°C (75°F)	5	0	0	0
10^{-6} m^3 (ml.) Foam After 10-Min. Settling				
a. Sequence I, 24°C (75°F)	0	0	0	0
b. Sequence II, 93°C (200°F)	0	0	0	0
c. Sequence III, 24°C (75°F)	0	0	0	0

NOTES: 1. <u>Chemical inertness</u>: KRYTOX® 143 oils have remarkable inertness, and show no reactions with the following materials at room temperature: ethyl alcohol, JP-4 turbine fuel, hydrazine, unsymmetrical dimethyl hydrazine, aniline, 90% hydrogen peroxide, inhibited red fuming nitric acid and nitrogen tetroxide. They also show no reaction with many acids at elevated temperatures.

(continued on next page)

These oils do not react with gaseous oxygen under shock loads at pressures of 51.7 x 10^6 N/m^2 (7,500 psi) and temperatures to 93°C (200°F). Passes "LOX" test per MSFC-Spec-106.

PERFLUOROALKYLPOLYETHER FLUIDS (E. I. du Pont de Nemours & Company)

PROPERTIES	KRYTOX® 143AX	KRYTOX® 143AC	KRYTOX® 143AD
DENSITY, kg/m^3 (lb/gal) at 24°C (75°F)	1,908 (15.9)	1,908 (15.9)	1,920 (16.0)
POUR POINT	-37°C (-35°F)	-34°C (-30°F)	-29°C (-20°F)
FLASH AND FIRE POINT	Products are Nonflammable		
VISCOSITY, 10^{-6} m^2/sec (Cs.) at -18°C (0°F)	13,800	33,000	-
38°C (100°F)	150	270	495
99°C (210°F)	16.4	26	43
204°C (400°F)	2.7	3.9	6.0
260°C (500°F)	-	2.1	3.0
VISCOSITY INDEX	125	134	145
ASTM SLOPE	0.625	0.589	0.549
THERMAL COEFFICIENT OF EXPANSION			
Vol/Vol - °C, Average from 25° to 99°C (x 10^4)	-	10.3	9.5
Vol/Vol - °F, Average from 77° to 210°F (x 10^4)	-	5.7	5.3
APPROXIMATE BOILING RANGE at			
0.8 mm. Hg., °C	251 to 270	-	-
at 0.8 mm. Hg, °F	484 to 518	-	-
VOLATILITY, Weight % Loss, 6.5 hr.			
at 149°C (300°F)	-	-	-
at 204°C (400°F)	-	1.0	-
at 260°C (500°F)	-	4.0	1.4
THERMAL DECOMPOSITION POINT			
Differential Thermal Analysis	471°C (880°F)	471°C (880°F)	471°C (880°F)
Isoteniscope	354°C (670°F)	354°C (670°F)	354°C (670°F)
VAPOR PRESSURE, mm. of Hg.			
at 149°C (300°F)	-	-	-
at 204°C (400°F)	-	0.3	0.1
at 260°C (500°F)	-	2.9	1.4
at 316°C (600°F)	-	19.3	9.0
at 371°C (700°F)	-	165.0	80.0
FOAMING CHARACTERISTICS (Test Method ASTM D-892)			
10^{-6} m^3 (ml.) Foam After 5-min. Blowing			
a. Sequence I, 24°C (75°F)	390	400	400
b. Sequence II, 93°C (200°F)	90	265	375
c. Sequence III, 24°C (75°F)	310	360	350
10^{-6} m^3 (ml.) Foam After 10-min. Settling			
a. Sequence I, 24°C (75°F)	20	0	100
b. Sequence II, 93°C (200°F)	0	0	20
c. Sequence III, 24°C (75°F)	50	0	200

NOTES:

2. Lubrication and load carrying: KRYTOX® 143 oils compare favorably with diester base stock containing no additives, synthetic hydraulic oils and petroleum-base E.P. type gear oils.

3. Compatibility: KRYTOX® oils are inert to most metals to 288°C (550°F), at higher temperatures oxidation-corrosion may develop. Also these fluorinated oils may detonate in the presence of aluminum or magnesium when metals are subject to shear such as in bearing surface, and tests are recommended. KRYTOX® oils are compatible with most elastomers below 93°C (200°F) except natural rubber, cis-1,4-polybutadiene, and SBR. At higher temperatures they cause deterioration of elastomers.

4. These oils have a usable temperature range from a low of their pour point to a high of 260°C (500°F) to 371°C (700°F).

LOW VISCOSITY, SYNTHETIC INSTRUMENT OIL
(ROYAL LUBRICANTS COMPANY)

PROPERTIES	ROYCO NO. 2 INSTRUMENT OIL
FLASH POINT	191°C (375°F)
FIRE POINT	210°C (410°F)
Pour POINT	-62°C (-80°F)
VISCOSITY, 10^{-6} m^2/sec (Cs.) at 38°C (100°F)	13.31
at 99°C (210°F)	2.91
EVAPORATION, 60 hr. at 66°C (150°F), % Wt. Loss	0.5
CARBON RESIDUE, % Wt.	0.03
ADDITIVES	Oxidation resistant
CORROSION, 72 hr. at 100°C (212°F)	No corrosion, or stain, on copper, cadmium plated steel, magnesium, aluminum or steel.

NOTE: ROYCO NO. 2 Instrument Oil is intended for use as an instrument lubricant where spreading of the oil into a thin film is required. Extreme low temperature properties for low temperature operation of "flea powered" equipment.

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MILITARY SPECIFICATION: MIL-G-3545 B

GREASE, AIRCRAFT, HIGH TEMPERATURE

PROPERTIES	SPEC. REQ.	ROYCO* 45A	AEROSHELL** GREASE 5	HIGH TEMP.*** GREASE
COLOR			Dark Amber	Greenish Tan
SPECIFIC GRAVITY, 16°C (60°F)	-	-	-	0.9160
DROPPING POINT	177°C (350°F)	232°C (450°F)	260+°C (500+°F)	210°C (410°F)
ODOR: (no rancidity or perfume)	Pass	Passes	Passes	Passes
CORROSION ON COPPER (24 hr. at 100°C (212°F) (no etching or pitting - stains removed by benzene)	Pass	Passes	Passes	Passes
PENETRATION: ASTM				
UNWORKED at -18°C (0°F)	-	-	-	122
UNWORKED at 25°C (77°F)	-	-	281	268
WORKED at 25°C (77°F)	250 - 300	280	282	288
DIRT CONTENT:				
25 10^{-6} m (micron) Dia. or Larger; Parts/10^{-6} m^3 (parts/cc)	5,000	300	-	Passes
75 10^{-6} m. (micron) Dia. or Larger; Parts/10^{-6} m^3	1,000	50	-	Passes
125 10^{-6} m. (micron) Dia. or Larger; Parts/10^{-6} m^3	None	0	-	Passes
BOMB OXIDATION STABILITY:				
Pressure Drop in 100 Hr.	68,950 N/m^2 (10 psi/max)	13,790 N/m^2 (2.0 psi)	27,580 N/m^2 (4.0 psi)	41,370 N/m^2 (6.0 psi)
Pressure Drop in 500 Hr.	172,370 N/m^2 (25 psi/max)	55,160 N/m^2 (8.0 psi)	89,630 N/m^2 (13.0 psi)	68,950 N/m^2 (10.0 psi)
WATER RESISTANCE; GREASE LOSS, 1.0 hr. at 66°C (150°F), % Weight	20 (max.)	4.0	1.0	2.5
HIGH TEMP. PERFORMANCE; 600 hr. at 149°C (300°F)	Pass	Passes	Passes	Passes
OIL SEPARATION; 30 hr. at 100°C (212°F), % Weight Loss, Max.	5.0	0.1	1.4	3.9
RUBBER SWELL; % Volume Increases, Max. (L-type syn. rubber in grease, 1.0 week)	10.0	8.5		
RUST PREVENTIVE PROPERTIES (number of small dots)	3.0 (max.)	Passes	Passes	Passes
LOW TEMPERATURE TORQUE:				
10^{-5} N m. (g. cm.) Starting Torque at -18°C (0°F), Max.	147,000 (15,000)	123,000 (12,500)	-	47,100 (4,800)
Running Torque at (0°F), Max.	49,000 (5,000)	1,860 (190)	-	4,410 (450)
STORAGE STABILITY: 6.0 Month at 38°C (100°F) (worked penetration change, points, max.)	30	Passes	-	Passes

MILITARY SPECIFICATION: MIL-G-3545 B

GREASE, AIRCRAFT, HIGH TEMPERATURE

PROPERTIES	SPEC. REQ.	ROYCO* 45A	AEROSHELL** GREASE 5	HIGH TEMP.*** GREASE
MEAN HERTZ LOAD	-	-	363 N (37 kg)	294 N (30 kg.)
USEFUL TEMPERATURE RANGE	-	-40°C to 191°C (-40°F - +375°F)	-40°C to 191°C (-40°F - +375°F)	-
THICKENER TYPE	-	Non-Soap	Microgel	Sodium soap
THICKENER; PERCENTAGE	-	-	-	13.5
OIL TYPE	-	Crude	Mineral	Mineral
OIL, PERCENTAGE	-		-	80.8
PROPERTIES OF OIL:				
GRAVITY, API	-	-	-	27.6
SPECIFIC GRAVITY, 16°C (60°F)	-	-	-	0.8894
POUR POINT,	-	-	-	-12°C (+10°F)
VISCOSITY; at 38°C (100°F),				
10^{-6} m^2/sec (Cs.)	-	-	-	291.4
at 99°C (210°F (Cs.)	-	-	32.8	21.5

* Royal Lubricants Company
** Shell Oil Company
*** Texaco, Incorporated

NOTES: For a description of this high speed, high temperature grease and recommended usage, see Section II.

In addition to the products listed, the following greases manufactured by the companies shown also meet the requirements of this specification: PED-3005, Standard Oil Co. of California; High Temperature Grease L-1231, Sinclair Refining Co.; 22440, International Lubricants; ANDOK 260, Humble Oil & Refining; Braycote 645, Bray Oil Company.

MILITARY SPECIFICATION: MIL-G-4343B

GREASE, PNEUMATIC SYSTEM

PROPERTIES	SPEC. REQ.	COSMOLUBE* 615	ROYCO** 43	55M*** GREASE
COLOR	-	Flesh - tan	-	Dark beige
SPECIFIC GRAVITY, 16°C (60°F)	-	-	-	-
DROPPING POINT, Min.	163°C (325°F)	193°C (380°F)	175°C (347°F)	207°C (405°F)
ODOR: (no rancidity or perfume)	Pass	Passes	Passes	Passes
NLGI NUMBER	-	-	2	-
CORROSION ON COPPER: 24 hr. at 100°C (212°F) (no etch or pitting - stain removed by benzene)	Pass	Passes	Passes	None
PENETRATION: ASTM,				
Unworked at 25°C (77°F)	-	-	-	-
Worked at 25°C (77°F)	260 - 300	286	269	275
APPARENT VISCOSITY: Max., 10^{-1} N sec/m^2 (passes); (at -54°C (-65°F) and Shear Rate, 20 sec^{-1})	5,000	2,508	2,750	3,400
OIL SEPARATION: 30 hr. at 100°C (212°F), % Weight Loss, Max.	5.0	3.51	0.3	1.5
EVAPORATION: 22 hr. at 99°C (210°F), % Weight Loss, Max.	2.5	0.76	1.9	1.9
OXIDATION (Bomb): Max. Pressure Drop	34,470 N/m^2 (5.0 psi)	2,070 N/m^2 (0.3 psi)	19,310 N/m^2 (2.8 psi)	< 34,470 N/m^2 (< 5.0 psi)
CYCLING TEST: Rubber-Metal, 50,000 Cycles	Pass		Passes	Passes
RUBBER SWELL: % Volume Increase (L-type synthetic rubber in grease - 1 week)	19 - 30	27.52	24.3	Passes
RUST PREVENTIVE PROPERTIES Number of Small Dots, Max.	3.0	Passes	None	Passes
STORAGE STABILITY: 6.0 Months at 38°C (100°F) (change in worked penetration, points, max.)	30	Passes	Passes	Passes
USEFUL TEMPERATURE RANGE		-54°C to 93°C (-65°F to +200°F)	Low-High	-54°C to 163°C (-65°F to +325°F)
GREASE COMPOSITION	-	Smooth	Buttery	-
Thickener	-	Metallic soap	Lithium	-
Fluid	-	Silicone	Synthetic	Silicone
Additives	-	Antioxidants	Antioxidants	-

GREASE, PNEUMATIC SYSTEM

PROPERTIES	SPEC. REQ.	COSMOLUBE* 615	ROYCO** 43	55M*** GREASE
RUBBER COMPATIBILITY: Buna "N"	-	Passes	Passes	Passes
MIL-P-5516 Rubber	-	Passes	Passes	Passes
LUBRICITY (Falex)	-	-	-	1,690 N (380 lb.)

* E. F. Houghton & Company
** Royal Lubricants Company
*** Dow Corning Corporation

NOTES: For a description and recommended usage of this high-low temperature range grease, compatible with rubber and possessing good metal-to-metal lubricating properties, see Section II.

In addition to the products listed, the following greases manufactured by the companies shown also meet the requirements of this specification.

Product Name	Manufacturer
Templube No. 124	National Engineering Products Company
Braycote 643	Bray Oil Company

MILITARY SPECIFICATION: MIL-G-6032B

GREASE, PLUG VALVE, GASOLINE AND OIL RESISTANT

PROPERTIES	SPEC. REQ.	ANDEROL* L-237	ROYCO** 32B
COLOR, ASTM	-	-	-
NLGI NUMBER	-	3.0	3.0
OIL TYPE (animal, vegetable or synthetic)	Note	Synthetic	Synthetic
GELLING AGENT	Note	-	Lithium
NO SOLID FILLERS (graphite, mica, sulfur, clay, asbestos or chalk)	Pass	Passes	Passes
SPECIFIC GRAVITY	-	0.95	-
DROPPING POINT, Min.	127°C (260°F)	182°C (360°F)	177°C (350°F)
USABLE TEMPERATURE RANGE	-	-29°C to 149°C (-20°F to +300°F)	-
NEUTRALIZATION NUMBER		0.5	
PENETRATION:			
Type I, 25°C (77°F), Unworked, Min.	100	190	-
Type I, 25°C (77°F), Worked, Max.	310	250	225
(1/4 scale), Type II, 25°C (77°F), Unworked, Max.	23	-	-
Type II, 25°C (77°F), Worked, Min.	20	-	-
CORROSION ON COPPER (no pitting or etching)	Pass	Passes	Passes
CORROSION ON STEEL (1 week at 100°C (212°F))	None	Passes	None
FILM STABILITY (1 week at 100°C (212°F))	Stable	Passes	Stable
STORAGE STABILITY; 120 Days at 54°C (130°F)			
No Stick Softening or Deterioration	Pass	Passes	Passes
Type II (1/4 scale) Unworked Penetration; Max.	23	-	-
No Stick Crumbling or Distortion	Req.	Passes	Passes
EVAPORATION, 22 hr. at 99°C (210°F), %	-	-	Nil
OIL SEPARATION, %	-	None	Nil
DIRT COUNT	-	None	-
RESISTANCE TO FUEL; 8 hr., Wt. Soluble, % Max.	20	Nil	15.0
Adhesion to Aluminum (no blisters or swelling)	Pass	Nil	None
RESISTANCE TO AQUEOUS SOLUTION, Water	None	Nil	Nil
50% Alcohol and Water	None	Nil	Nil
SOLUBILITY, MIL-H-3136, %	-	10	-
Mixed Alcohols, %	-	31	-
Mixed Keotane, %	-	45	-
Toluene, %	-	90	-
Benzene, %	-	100	-
Carbon Tetrachloride, %	-	100	-

MILITARY SPECIFICATION: MIL-G-6032B

GREASE, PLUG VALVE, GASOLINE AND OIL RESISTANT

PROPERTIES	SPEC. REQ.	ANDEROL* L-237	ROYCO** 32B
COMPATIBILITY WITH ROCKET FUELS			
Fuming Nitric Acid	-	-	No
Liquid Oxygen	-	-	No
Hydrogen Peroxide	-	-	No
Fluorine	-	-	No

* Lehigh Chemical Company
** Royal Lubricants Company

NOTES: For a description and recommended usage of this gasoline and oil resistant grease see Section II.

In addition to the products listed, the following grease manufactured by the companies shown also meet the requirements of this specification.

Product Name	Manufacturer
Braycote 632	Bray Oil Company
Rockwell 950	Rockwell Manufacturing Company
E-Z Turn Lubricant	United Oil Manufacturing Company

MILITARY SPECIFICATION: MIL-G-7187

GREASE, GRAPHITE, AIRCRAFT LUBRICATING

PROPERTIES	SPEC. REQ.	ROYCO* 87R	AIRCRAFT** STARTER GREASE
COLOR	-	Black	Black
SPECIFIC GRAVITY; 16°C (60°F)	-	-	0.9053
COMPOSITION: Mineral Oil, %	-	-	74.2
Gelling Agent	-	Soap	Soap
Graphite, %	4.5 - 5.5	5.0	5.2
Water	-	-	Trace
ODOR (no rancidity or perfume)	Pass	Passes	Passes
DROPPING POINT, Min.	149°C (300°F)	149°C - 177°C (300°F - 350°F)	156°C (312°F)
PENETRATION, ASTM; Unworked, -18°C (0°F)	-	-	203
Unworked, 25°C (77°F)	-	-	258
Worked, 25°C (77°F)	265 - 340	300	275
CORROSION ON COPPER; 24 hr. at 100°C (212°F)	None	None	Passes
BOMB OXIDATION: 100 hr. at 99°C (210°F), Pressure Drop, Psi,	5.0 (Max.)	< 5.0	Passes
WATER RESISTANCE; 1.0 hr. at 38°C (100°F), Wt. Loss, % (max.)	50.0	Passes	Passes
EVAPORATION: 22 hr. at 99°C (210°F); Wt. Loss, % (max.)	2.0	< 2.0	Passes
OIL SEPARATION: 30 hr. at 25°C (77°F), Wt. Loss, % (max.)	5.0	< 5.0	Passes
LOW TEMPERATURE TORQUE: At -40°C (-40°F) (ball bearing)			
Clockwise; 0.1962 N m. (2,000 g. cm.) Torque; Time/Rev.; (sec.)	10.0 (Max.)	Passes	5.0
Counter-Clockwise; 0.1962 N m. (2,000 g. cm.) Torque; Time; Rev., Sec.	10.0 (Max.)	Passes	5.0
WORKED STABILITY; Worked Penetration After 10^5 Cycles	375 (Max.)	< 375	313
AERATION TEST: 60 min. at 1,000 rpm; % Vol. Increase	15 (Max.)	Passes	Passes
STORAGE STABILITY: 6 Months at 38°C (100°F), Penetration Change	± 20 (Max.)	-	-
SPEED RANGE	-	Low	Low
USABLE TEMPERATURE RANGE	-	Medium	Medium
USABLE IN BALL OR ROLLER BEARINGS	-	No	No
USABLE ON PLAIN BEARING AND SLIDING SURFACES	-	Yes	Yes
USABLE ON ELECTRICAL EQUIPMENT	-	No	No
RUST INHIBITED (additives)	-	Yes	No

* Royal Lubricants Company
** Texaco, Incorporated

NOTES: For a description and recommended usage of this long-life graphite grease, see Section II.

MILITARY SPECIFICATION: MIL-G-10924B

GREASE, AUTOMOTIVE AND ARTILLERY

PROPERTIES	SPEC. REQ.	ROYCO* 24R
COLOR	-	-
NLGI NO.	-	-
COMPOSITION: Oil Type	-	Mineral
Thickener Type	-	Lithium soap
Thickener Content, % Wt. Min.	10.0	-
Antioxidant Additive	-	Yes
PENETRATION: Unworked, at 25°C (77°F)	265 - 295	-
Worked, at 25°C (77°F)	265 - 295	265 - 295
APPARENT VISCOSITY: 10^{-1} N sec/m^2 (poises),		
at -54°C (-65°F) and Shear Rate, 25 sec^{-1}	11,500 - 17,500	-
at -54°C (-65°F) and Shear Rate, 100 sec^{-1}	8,500 (Max.)	< 8,500
EVAPORATION: 22 hr. at 99°C (210°F), % Wt. Loss, Max.	10.0	< 10.0
SEPARATION: 30 hr. at 100°C (212°F), % Wt. Loss, Max.	6.0	Passes
OXIDATION STABILITY: 400 hr. at 99°C (210°F), Pressure Loss/100 hr. (max.)	34,470 N/m^2 (5.0 psi)	Passes
COPPER STRIP CORROSION: 20 hr. at 99°C (210°F)	None	Passes
RUST PREVENTION: Roller Bearing; 2 weeks at 25°C (77°F), 100° RH	None	Passes
STORAGE STABILITY: 6 Months at 38°C (100°F), Penetration, Min.	255	Stable
WORK STABILITY: 100 hr., 66°C (150°F), 10 rpm. Allowable Change in Worked Penetration	-25 to +45	Passes
WATER STABILITY: Worked in Water 10^5 Cycles at 25°C (77°F) Allowable Change in Worked Penetration	-10 to +45	Passes

* Royal Lubricants Company

NOTES: For a description of this general purpose grease see Section II.

In addition to the product listed, several other general purpose greases also meet the requirements of this specification. Some of these are:

Product Name	Distributor
Batco 1000 and 2000 (1)	Battenfeld Grease & Oil Company of New York
Cycleweld L-874 (1)	Chemical Division of Chrysler Corporation
Dura Lube M-12B (1)	Franklin Oil Corporation
Cosmolube 506 (1)	E. F. Houghton & Company
Shell B & B Grease (2)	Shell Oil Company
Code ILC 22122	International Lubricant Corporation

(1) Rebranded; manufactured by Southwest Grease & Oil, Inc.
(2) Rebranded; manufactured by International Lubricant Corp.

MILITARY SPECIFICATION: MIL-L-15719

LUBRICATING GREASE (HIGH-TEMPERATURE ELECTRIC MOTOR, BALL AND ROLLER BEARINGS)

PROPERTIES	SPEC. REQ.	DOW CORNING* 44 GREASE	VERSILUBE** G-350
COLOR	-	Light brown	Light brown
SPECIFIC GRAVITY, 16°C (60°F)	-	-	1.05
ODOR (no rancidity or perfume)	Pass	Passes	Passes
COMPOSITION, Polymethylphenyl Silicone			
Fluid	Req.	Passes	Passes
Lithium Soap	Req.	Passes	Passes
Additives	-	-	-
PENETRATION, Worked, at 25°C (77°F)	260 to 330	290 to 330	260 to 330
DROPPING POINT, Min.	191°C (375°F)	Passes	224°C (435°F)
DIRT (number of particles/10^{-6} m^3)			
25×10^{-6} m^3 (microns) Dia. or Above, Max.	7,500	Passes	-
75×10^{-6} m^3 (microns) Dia. or Above, Max.	1,600	Passes	-
125×10^{-6} m^3 (microns) Dia. or Above, Max.	None	Passes	-
COPPER CORROSION (bomb), 20 hr. at 99°C (210°F) (no etch or pit)	Pass	Passes	
EVAPORATION, 50 hr. at 149°C (300°F), % Weight Loss, Max.	2.0	< 2.0	< 2.0
WATER RESISTANCE (8 ball bearing); 1.0 hr. at 49°C (120°F), % Weight Loss, Max.	20.0	Passes	
BLEEDING, 100 hr. at 149°C (300°F), % Weight Loss, Max.	12.0	5.0	5.0
OXIDATION STABILITY, 50 hr. at 149°C (300°F), Pressure Drop, Max.	34,470 N/m^2 (5.0 psi)		
WORK STABILITY, 10^5 Cycles, Penetration, Max.	375.0		
APPARENT VISCOSITY, 10^{-1} N sec/m^2 (poises), Max. (at -18°C (0°F) and Shear Rates, 20 sec^{-1})	10,000		
LOW TEMP. TORQUE, 2 hr. at -18°C (0°F), Torque = 0.1962 N m. (2,000 g. cm.) Time for One Rev.; Sec.	15.0 Max.		
MOTOR TEST PERFORMANCE (bearing); Useful Life, Hours, Minutes	2,000	Passes	-
USABLE TEMPERATURE RANGE	-	-40°C to 204°C (-40°F to 400°F)	-40°C to 204°C (-40°F to 400°F)
LUBRICITY (falex)		1,068 N (240 lb.)	-
MAXIMUM SPEED FACTOR, DN Value		200,000	-

* Dow Corning Corporation

** General Electric, Silicone Products Department

NOTES: For a description and recommended usage of this low or high temperature silicone base grease, See Section II.

MILITARY SPECIFICATION: MIL-G-18709A (NAVY)

GREASE, BALL AND ROLLER BEARING

PROPERTIES	SPEC. REQ.	REGAL* AFB 2	ANDOK B **	NEBULA** EP-1
COLOR	Brown	Brown	Brown	Tan
NLGI NUMBER	-	2.0	-	1
ODOR: (slight mineral oil or soap)	Pass	Passes	Passes	Passes
COMPOSITION:				
Oil Type	-	Mineral	Mineral	Mineral
Gelling Agent	-	Lithium soap	Sodium soap	Calcium soap
Additives	-	Antirust	-	-
PENETRATION:				
Unworked at 25°C (77°F)	-	285	-	-
Worked at 25°C (77°F)	-	285	285	325
Worked 10^5 Cycles at 25°C (77°F)	-	320	-	325 ± 5%
DROPPING POINT, Min.	149°C (300°F)	203°C (398°F)	246°C (475°F)	< 260°C (< 500°F)
APPARENT VISCOSITY: 10^{-1} N sec/m2 (poises), Max. (at 0°C (32°F) and shear rate, 200 sec^{-1})	750	-	-	-
USABLE SPEED RANGE	-	< 10,000 rpm	High speed	High & low
PERFORMANCE: Ball Bearing at 121°C (250°F), Min. Life, Hr.	2,000	> 2,000	Passes	> 2,000
LOAD CAPACITY: (hertz)	-	67 N (15 lb.)	-	240 N (54 lb.)
RUBBER SWELL: % Gain	-	16.6	-	-
LOW TEMPERATURE TORQUE: At -40°C (-40°F) - Starting Torque,	-	0.7293 N m. (7,434 g. cm.)	Low	Low
Running Torque	-	0.0521 N-m (531 g. cm.)	Low	Low

* Texaco

** Humble Oil & Refining Company

NOTES: For a description and recommended usage of this general purpose ball and roller bearing grease, see Section II.

In addition to the products listed, several other greases meet the requirements of this specification. Some of these are:

Product Name	Manufacturer
Supermil Grease No. 90781	American Oil Company
Atlantic Lubricant 52	Atlantic Refining Company
B & RB Grease No. 2 & No. 3	International Lubricant Corporation
HVI Microgel Grease No. 2	International Lubricant Corporation
Alvania Grease 2	Shell Oil Company
Shell Darina Grease 2	Shell Oil Company
Shell Cyprina Grease 3	Shell Oil Company
XTR 20	Socony Mobil Oil Company, Inc.
Mobilplex	Socony Mobil Oil Company, Inc.
Chevron OHT Grease	Standard Oil Company of California
Calolmil Grease 121	Standard Oil Company of California
Southwest No. 3212	Southwest Grease & Oil Company, Inc.

MILITARY SPECIFICATION: MIL-G-21164C

GREASE, MOLYBDENUM DISULFIDE (FOR LOW AND HIGH TEMPERATURES)

PROPERTIES	SPEC. REQ.	AEROSHELL* GREASE 17	ROYCO** 64	PED-*** 3350
NLGI NUMBER	-	-	2.0	-
COLOR	-	Dark grey	Grey-black	-
COMPOSITION:				
Liquid Lubricant	-	Diester Synthetic	Synthetic	Napthenic Paraffinic
Thickener (gelling agent)	-	Microgel	Lithium	Polyurea
Molybdenum Disulfide, %	4.5 - 5.5	Passes	Passes	Passes
Additives: Rust Inhibitor	-	-	Yes	Yes
Oxidation Inhibitor	-	-	Yes	Yes
Extreme Pressure	-	-	Yes	Yes
DROPPING POINT, Min.	163°C (325°F)	> 260°C (> 500°F)	185°C (365°F)	228°C (442°F)
USEFUL TEMPERATURE RANGE, °F		-62°C - 149°C (-80°F - 300°F)	Wide	-
PENETRATION: Unworked at 25°C (77°F)	200 Min.	273	-	-
Worked at 25°C (77°F)	260 - 310	281	285	295
APPARENT VISCOSITY: 10^{-1} N sec/m^2 (poises)				
at -54°C (-65°F) and Shear Rate, 20 sec^{-1}		-	5,000	6,700
at -54°C (-65°F) and Shear Rate, 50 sec^{-1}		-	3,000	4,250
CORROSION ON COPPER: 24 hr. at 100°C (212°F) (no etch or pit)	Pass	Passes	None	Passes
EVAPORATION: 22 hr. at 99°C (210°F), % Weight Loss, Max.	2.0	0.8	2.0	1.2
BOMB OXIDATION: 100 hr. at 99°C (210°F), Pressure Drop, Max.	68,950 N/m^2 (10 psi)	27,580 N/m^2 (4.0 psi)	-	-
500 hr. at 99°C (210°F), Pressure Drop, Max.	103,420 N/m^2 (15 psi)	82,740 N/m^2 (12.0 psi)	44,820 N/m^2 (6.5 psi)	-
OIL SEPARATION: 30 hr. at 100°C (212°F), % Weight Loss, Max.	5.0	< 4.6	3.0	1.9
BEARING RUST PROTECTION: 14 Days (3 dots max.)	Pass	Passes	None	Passes
WATER RESISTANCE: 1.0 hr. at 38°C (100°F), % Weight Loss, Max.	20.0	1.4	6.0	4.4
WORK STABILITY: 10^5 Cycles, Penetration, Max.	375		340	308
LOW TEMPERATURE TORQUE: -73°C (-100°F) at Starting Torque, Max.	0.981 N m. (10,000 g. cm.)	-	Passes	Passes
at Running Torque, Max.	0.0981 N m. (1,000 g. cm.)	-	Passes	Passes

GREASE, MOLYBDENUM DISULFIDE (FOR LOW AND HIGH TEMPERATURES)

PROPERTIES	SPEC. REQ.	AEROSHELL* GREASE 17	ROYCO** 64	PED-*** 3350
HIGH TEMPERATURE TEST:				
Bearing Life at 121°C (250°F) hr., Min.	1,000	3,400	> 2,000	
LOAD-WEAR INDEX (mean hertz load), Min.	491 N (50 kg.)	932 N (95 kg.)	491 N (50 kg.)	755 N (77 kg.)
DIRT CONTENT: Parts/10^{-6} m^3 (particles/cc)				
25 x 10^{-6} (microns) or Larger	-	-	750	-
75 x 10^{-6} (microns) or Larger	-	-	150	-
125 x 10^{-6} (microns) or Larger	-	-	None	-
STORAGE STABILITY: 6 Months at 38°C (100°F)				
Unworked Penetration, Min.	200 points	Passes	Passes	Passes
Worked Penetration Change, Max.	30 points	Passes	Passes	Passes

* Shell Oil Company
** Royal Lubricants Company
*** Standard Oil Company of California

NOTES: For a description and recommended usage of this wide temperature range, molybdenum disulfide grease, see Section II.

In addition to the products listed, there are other greases manufactured and other lubricant companies which meet the requirements of this specification. Some of these are:

Product	Manufacturer
TG-4727 Grease	Texaco, Inc.
Electro-Moly/11	Electrofil, Inc.
Braycote 664	Bray Oil Company

MILITARY SPECIFICATION: MIL-G-23549 A (ASG)

GREASE, GENERAL PURPOSE

PROPERTIES	SPEC. REQ.	ROYCO* 49	LAUNCH PAD** GREASE
COLOR	-	Grey-black	-
COMPOSITION:			
OIL TYPE	-	Mineral	Paraffinic
THICKENER	-	Non-soap	Calcium
ADDITIVES: RUST INHIBITOR	-	Yes	Yes
OXIDATION INHIBITOR	-	Yes	-
EXTREME PRESSURE	-	-	Yes
SOLID LUBRICANT	-	MoS_2	Yes
DROPPING POINT, Min.	232°C (450°F)	282°C (540°F)	270°C (518°F)
MAX. USABLE TEMP.	-	204°C (400°F)	-
PENETRATION: WORKED AT 25°C (77°F)	270 - 315	300	300
COPPER CORROSION; 24 hr. at 177°C (350°F) (no pit or etch)	Pass	Passes	Passes
SALT SPRAY; 48 hr. at 35°C (95°F) (no corrosion)	Pass	Passes	Passes
OIL SEPARATION: 30 hr. at 177°C (350°F), % Wt. Loss, Max.	6.0	5.0	2.2
EVAPORATION: 22 hr. at 177°C (350°F), % Wt. Loss, Max.	7.0	6.0	2.0
BOILING WATER: 10.0 Min., (no disintegration)	Pass	Passes	Passes
LOAD CARRYING CAPACITY (mean hertz), Min.	491 N (50 kg.)	491 N (50 kg.)	736 N (75 kg.)
STORAGE STABILITY: 6 Months, at 38°C (100°F), Points (max. change in worded penetration)	± 30	Stable	Passes

* Royal Lubricants Company

** Standard Oil Company of California

NOTES: For a description and recommended usage of this general purpose grease, see Section II.

In addition to the greases listed, other greases which meet the requirements of this specification are:

Product	Manufacturer
Grease 22443	International Lubricants Company
Grease XRR 3	Socony Mobil Oil Company

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MILITARY SPECIFICATION: MIL-G-23827A

GREASE, AIRCRAFT AND INSTRUMENT, GEAR AND ACTUATOR SCREW

PROPERTIES	SPEC. REQ.	ROYCO 27*	AEROSHELL** GREASE 7 A	UNITEMP*** EP
COLOR	-	-	Amber	Tan
ODOR (no objectionable odors)	Pass	-	-	-
COMPOSITION, Oil Type	-	Synthetic	Synthetic	Synthetic
Thickener	-	Lithium	Microgel	Lithium
Additives	-	Oxidation Extreme pressure	-	Oxidation Extreme pressure
DROPPING POINT, Min.	163°C (325°F)	188°C (370°F)	260°C (500°F)	185°C (365°F)
USEFUL TEMPERATURE RANGE	-	-	-62°C to 149°C (-80°F to 300°F)	-54°C to 121°C (-65°F to 250°F)
PENETRATION, Unworked at 25°C (77°F), Min.	200	280	276	293
Worked at 25°C (77°F)	270 to 310	290	294	288
DIRT CONTENT, Particles/ 10^{-6} m^3 (particles/ml) of Grease				
25×10^{-6} m. (microns) Diameter or Larger	1,000	450	-	-
75×10^{-6} m. (microns) Diameter or Larger	None	0	-	-
OXIDATION STABILITY, 100 hr. at 99°C (210°F) Pressure Drop, Max.	68,950 N/m^2 (10 psi)	10,340 N/m^2 (1.5 psi)	27,580 N/m^2 (4.0 psi)	
500 hr. at 99°C (210°F) Pressure Drop, Max.	103,420 N/m^2 (15 psi)	34,480 N/m^2 (5.0 psi)	55,160 N/m^2 (8.0 psi)	
COPPER CORROSION (bomb test), 20 hr. at 99°C (210°F) Pressure Drop, Max.	6,895 N/m^2 (1.0 psi)	0.0		
Copper Strip (no corrosion)	Pass	Pass	Pass	-
Grease (no discoloration	Pass	Pass	-	-
WATER RESISTANCE, 1.0 hr. at 38°C (100°F), % Weight Loss, Max.	20.0	2	0.8	0
EVAPORATION, 22 hr. at 99°C (210°F), % Weight Loss, Max.	2.5	2.1	0.75	1.1
OIL SEPARATION, 30 hr. at 100°C (212°F), % Weight Loss, Max.	5.0	2.9	4.1	2.7
LOW TEMPERATURE TORQUE, at -73°C (100°F)				
Starting Torque, Max.	0.981 N m. (10,000 g. cm.)	0.241 N m. (2,450 g. cm.)	-	-
Running Torque, Max.	0.0981 N m. (1,000 g. cm.)	0.0216 N m. (220 g. cm.)	-	-

GREASE, AIRCRAFT AND INSTRUMENT, GEAR AND ACTUATOR SCREW

PROPERTIES	SPEC. REQ.	ROYCO 27*	AEROSHELL** GREASE 7 A	UNITEMP*** EP
HIGH TEMPERATURE BEARING TEST at 121°C (250°F), Min. Life, hr.	1,000	Passes	1,250	1,494
LOAD CARRYING CAPACITY (mean hertz load), Min.	294 N (30 kg.)	339 N (34.6 kg.)	608 N (62 kg.)	373 N (38 kg.)
GEAR WEAR, 10^{-6} kg/1,000 Cycles (mg/1,000 cycles)				
22.24 N (5 lb.) Load, Max. Wear	2.5	1.5	-	-
44.48 N (10 lb.) Load, Max. Wear	3.5	2.0	-	-
WORKED STABILITY, 10^5 Cycles at 25°C (77°F), Worked Penetration	375 (max.)	340	Passes	322
RUST PREVENTIVE PROPERTIES (14-day bearing test at 25°C (77°F), 100% RH) No Discoloration or Corrosion in Excess of 3 Small Spots	Passes	Passes	Passes	Passes
STORAGE STABILITY, 38°C (100°F) for 6 Months				
Penetration Unworked at 25°C (77°F), Min.	200	290	Passes	Passes
Change in Worked Penetration at 25°C (77°F)	± 30	290	Passes	Passes

* Royal Lubricants Company
** Shell Oil Company
*** Texaco, Incorporated

NOTES: This specification supersedes the following grease MIL specifications: MIL-G-7718A, MIL-G-007118B, MIL-G-7421B, MIL-G-3278A, and MIL-G-15793.

For a description of this aircraft and instrument grease, and recommended usage, See Section II.

In addition to the products listed, other greases which meet the requirements of this specification are:

Product	Manufacturer
Supermil Grease No. 72832	American Oil Company
Cosmolube 678	E. F. Houghton and Company
Mobilgrease 27	Socony Mobil Oil Company
PED-3527	Standard Oil Company of California

GREASE, AIRCRAFT, BALL AND ROLLER BEARING

PROPERTIES	SPEC. REQ.	SUPERMIL* ASU GREASE NO. 31052	JET** HI-TEMP. GREASE	AEROSHELL*** GREASE 15
COLOR	-	-	-	Blue
COMPOSITION: Oil Type	-	Silicone	Silicone	Silicone Synthetic
Thickener	-	Arylurea	Pigment Gel Agent	Organic Dye
Additives	-	-	Oxidation Antirust	-
USEFUL TEMPERATURE RANGE		-73°C to 232°C (-100°F to +450°F)	232°C (450°F)	-73°C to 316°C (-100°F to +600°F)
DROPPING POINT, Min.	232°C (450°F)	Passes	253°C (488°F)	> 260°C (> 500°F)
PENETRATION: Unworked at 25°C (77°F)	-	-	250	284
Worked at 25°C (77°F)	260-330	300	288	311
COPPER CORROSION: 24 hr. at 100°C (212°F) (no pit or etch)	Pass	Passes	Passes	Passes
LOW TEMPERATURE TORQUE: at -54°C (-65°F) Starting Torque; Max.	0.1962 N m. (2,000 g. cm.)	Passes	0.0752 N m. (767 g. cm.)	
Running Torque (after 1 hr.); Max.	0.0490 N m. (500 g. cm.)	Passes	0.00873 N m. (89 g. cm.)	
OXIDATION STABILITY (bomb test) at 121°C (250°F), Pressure Drop in 100 hr., Max.	34,480 N/m^2 (5.0 psi)	0	0	13,790 N/m^2 (2 psi)
WATER RESISTANCE: 1.0 hr. at 38°C (100°F), % Wt. Loss, Max.	20.0	1.4	0.4	6
HIGH TEMP. PERFORMANCE: (bearing life) at 232°C (450°F), Hr.	500 (min.)	> 500	1,833	1,900
EVAPORATION: 22 hr. at 204°C (400°F), % Wt. Loss, Max.	4.0	4.0	4.0	1.6
OIL SEPARATION: 30 hr. at 204°C (400°F), % Wt. Loss, Max.	7.5	6.8	3.9-4.5	4.8
RUST PREVENTIVE PROPERTIES (14 days) days): (no discoloration or corrosion in excess of 3 small spots per bearing; no pitting or etching)	Passes	Passes	Passes	Passes
WORK STABILITY: at 25°C (77°F), 10^5 Cycles, Worked Penetration	375 (max.)		294	

GREASE, AIRCRAFT, BALL AND ROLLER BEARING

PROPERTIES	SPEC. REQ.	SUPERMIL* ASU GREASE NO. 31052	JET** HI-TEMP. GREASE	AEROSHELL*** GREASE 15
STORAGE STABILITY: 6 Months at 38°C (100°F)				
Unworked Penetration at 24°C (77°F), Min.	200	Passes	Passes	Passes
Worked Penetration Change at 24°C (77°F), Max.	± 30	Passes	Passes	Passes

* American Oil Company
** Texaco, Incorporated
*** Shell Oil Company

NOTES: For a description and recommended usage of this wide temperature range bearing grease, see Section II.

In addition to the products listed, other greases which meet the requirements of this specification are:

Product	Manufacturer
Mobil Grease 24	Socony Mobil Oil Company

This specification supersedes MIL-G-27343A (ASG), "Grease, Ball and Roller Bearing, For Temperature Ranging From -73°C to +204°C (-100°F to +400°F)."

MILITARY SPECIFICATION: MIL-G-25537A (ASG)

GREASE, AIRCRAFT: HELICOPTER OSCILLATING BEARING

PROPERTIES	SPEC. REQ.	AEROSHELL* GREASE 14	ROYCO** 37R
COLOR	-	Tan	Light brown
ODOR (nonobjectionable, no rancidity, perfume or alcohol)	Pass	Passes	Passes
COMPOSITION:			
Oil Type	-	Mineral	-
Gelling Agent	-	Calcium soap	-
Additives	-	-	Wear and oxidation
DROPPING POINT, Min.	138°C (280°F)	146°C (295°F)	143°C (290°F)
PENETRATION:			
Unworked at 25°C (77°F)	200 to 305	282	290
Worked at 25°C (77°F)	265 to 305	289	295
Worked 10^5 Cycles at 25°C (77°F)	265 to 375	-	300
APPARENT VISCOSITY, 10^{-1} N sec/m^2 (poises), at -54°C (-65°F) and Shear Rate, 25 sec^{-1} at -54°C	15,000	-	10,000
(-65°F) and Shear Rate, 100 sec^{-1}	7,000	-	5,000
DIRT CONTENT (number of particles/ 10^{-6} m^3, particles/cc)			
25 x 10^{-6} m^3 (microns) or above	5,000	-	950
75 x 10^{-6} m^3 (microns) or above	1,000	-	10
125 x 10^{-6} m^3 (microns) or above	None	-	0
EVAPORATION, 22 hr. at 99°C (210°F), % Weight Loss, Max.	7.0	5.0	5.0
OIL SEPARATION, 30 hr. at 100°C (212°F), % Weight Loss, Max.	5.0	1.8	< 5.0
CORROSION ON COPPER, 24 hr. at 100°C (212°F) (no pit or etch)	Pass	Passes	None
OXIDATION (bomb); 400 hr. at 99°C (210°F), Max. Pressure Drop/100 hr.	34,480 N/m^2 (5.0 psi)	6,895 N/m^2 (1.0 psi)	6,895 N/m^2 (1.0 psi)
WATER STABILITY, Worked 10^5 Strokes in Water: Worked Penetration Change, Max.	70		Passes
RUST PREVENTIVE (bearing), 2 weeks at 25°C (77°F), 100% RH, Max.	3 Spots	Passes	None
OSCILLATION (bearing test); Life, Hours	250 (min.)	Passes	> 250
STORAGE STABILITY, 6 Months at 38°C (100°F), Unworked Penetration	200 to 305	Passes	Stable
Worked Penetration	265 to 305	Passes	Stable
USEFUL TEMPERATURE RANGE	-	-54°C to 121°C (-65°F to +250°F)	-54°C to 93°C (-65°F to +200°F)
USEFUL SPEED RANGE		Slow to medium	Slow to medium

* Shell Oil Company

** Royal Lubricants Company

NOTES: For a description and recommended usage of this bearing grease, having good low temperature and shear resistance properties, see Section II.

MILITARY SPECIFICATION: MIL-G-27549 (USAF)

GREASE, AIRCRAFT, HEAVY LOAD-CARRYING

PROPERTIES	SPEC REQ.	COSMOLUBE 5100
COLOR	-	Lavender
COMPOSITION		
Oil Type	-	Silicone
Thickener	Non-soap	Non-soap organic
Additives	-	EP-oxidation/ corrosion
DROPPING POINT, Min.	232°C (450°F)	> 260°C (> 500°F)
USEFUL TEMPERATURE RANGE	-	-54°C to 218°C (-65°F to 425°F)
PENETRATION, Worked at 25°C (77°F)	270 to 340	281
WORK STABILITY, 10^5 Cycles at 24°C (77°F), Penetration, Max.	375	325
EVAPORATION, 22 hr. at 204°C (400°F), % Weight Loss, Max.	10.0	4.75
OIL SEPARATION, 30 hr. at 204°C (400°F), % Weight Loss, Max.	7.5	6.27
APPARENT VISCOSITY, 10^{-1} N sec/m^2 (poises) Max. at -54°C (-65°F) and Shear Rate, 20 sec^{-1}	20,000	728
BEARING PROTECTION, 2 weeks at 25°C (77°F) & 100% RH (3 spots visible to naked eye, Rating 2	2.0	Passes
MEAN HERTZ LOAD, Min.	589 N (60.0 kg.)	836 N (85.2 kg.)
WATER RESISTANCE, 1.0 hr. at 38°C (100°F), % Weight Loss, Max.	20.0	1.0
STORAGE STABILITY, 6 Months at 38°C (100°F), Unworked		
Penetration, Min.	200.0	Passes
Worked Penetration Change, Max.	± 30.0	Passes
OSCILLATION TEST (bearing test), 218°C (425°F), 250 cycles/min., and 17,790(4,000 lb.), Min. Cycles	200,000	Passes
LOW TEMPERATURE TORQUE (bearing test) at -54°C (-65°F),		
Starting Torque, Max.	0.491 N m. (5,000.0 g. cm.)	Passes
Running Torque, Max.	0.0491 N m. (500.0 g. cm.)	Passes
COMPATIBILITY, Buna "N" & MIL-P-5516 Rubber	-	Yes
Paint & Lacquers	-	Yes
Plastics	-	Yes
Insulation & Coated Fabrics	-	Yes

* E. F. Houghton & Company

NOTE: For a description and recommended usage of this load carrying grease, see Section II.

MILITARY SPECIFICATION: MIL-G-25760A(ASG)

GREASE, AIRCRAFT, BALL AND ROLLER BEARING, WIDE TEMPERATURE RANGE

PROPERTIES	SPEC. REQ.	ROYCO* 60R	AEROSHELL** GREASE 16	SUPERMIL*** ASU GREASE NO. 06752
COLOR	-	Light tan	Dark amber	-
COMPOSITION, Oil Type	-	Diester syn.	Synthetic	Ester
Gelling Agent	High melting	-	Microgel	Arylurea
Additives	-	Wear, rust Oxidation	-	-
DROPPING POINT, Min.	260°C (500°F)	282°C (540°F)	260°C (500°F)	260°C (500°F)
PENETRATION, Unworked at 25°C (77°F)	-	300	274	-
Worked at 25°C (77°F)	260 to 320	300	280	315
CORROSION ON COPPER, 24 hr. at 100°C (212°F), No Pitch or Etch	Pass	Passes	Passes	
OXIDATION STABILITY (bomb) at 99°C (210°F), Pressure Drop, Max/100 hr.	34,480 N/m^2 (5 psi)	6,895 N/m^2 (1 psi)	27,580 N/m^2 (4.0 psi)	6,895 N/m^2 (1.0 psi)
WATER RESISTANCE, % Weight Loss, Max.	< 50	1	2	5
HIGH TEMP. PERFORMANCE, Bearing at 177°C (350°F), hr. (min.)	400 Hr.	> 450	> 600	> 400
EVAPORATION, 22 hr. at 177°C (350°F), % Loss, Max.	7	5	5	4.9
OIL SEPARATION, 30 hr. at 177°C (350°F), % Loss, Max.	5	2.5	4.6	3
APPARENT VISCOSITY, 10^{-1} N sec/m^2 (poises), Max. at -40°C (-40°F) and Shear Rate, 20 sec^{-1}	15,000	9,000		
STEEL-ON-STEEL WEAR (shell four ball), 1,200 rpm at 75°C (167°F), 392 N (40 kg.) for 120 min., Wear Scar, Max. Avg. Dia., 10^{-3} m.	1.3	0.8		
BEARING PROTECTION, Rust Preventive, 2 Weeks at 25°C (77°F), 100% RH, Max.	3 Spots	None	Passes	
STORAGE STABILITY, 6 Months at 38°C (100°F) Unworked Penetration, Min.	≥ 200	Stable	-	-
Worked Penetration	260 to 320	-	-	-
USABLE TEMPERATURE RANGE	-	-54°C to 177°C (-65°F to +350°F)	-54°C to 204°C (-65°F to +400°F)	-54°C to 177°C (-65°F to +350°F)

GREASE, AIRCRAFT, BALL AND ROLLER BEARING, WIDE TEMPERATURE RANGE

PROPERTIES	SPEC. REQ.	ROYCO* 60R	AEROSHELL** GREASE 16	SUPERMIL*** ASU GREASE NO. 06752
MEAN HERTZ LOAD, or Load Capacity	-	-	559 N (57 kg.)	Medium
COMPATIBILITY WITH NATURAL RUBBER & NEOPRENE	-	No	No	No

* Royal Lubricant Company
** Shell Oil Company
*** American Oil Company

NOTES: This specification has been superseded by MIL-G-81322, "Grease, Aircraft, General Purpose, Wide-Temperature Range;" however, because of limited grease qualified to this new specification, these greases for the older specifications are included. For description and recommended usage, see Section II.

In addition to the products listed, several other wide temperature greases also meet the requirements of this specification. Some of these are:

Product Name	Manufacturer
Grease TG-4971	Texaco, Inc.
Braycote 660S	Bray Oil Company

MILITARY SPECIFICATION: MIL-G-27617 (USAF)

GREASE, AIRCRAFT, FUEL AND OIL RESISTANT

PROPERTIES	SPEC. REQ.	FS-1292*	PR-240**
COLOR	-	Off-white	White
COMPOSITION, Liquid Lubricant	-	Fluorosilicone	PR-143
Viscosity at 38°C (100°F), 10^{-6} m^2/sec (Cs.)	-	-	285
at 99°C (210°F), 10^{-6} m^2/sec (Cs.)	-	-	25.5
Pour Point	-	-	-29°C (-20°F)
Gelling Agent	-	High-melt Solid	"Vydex" 1000 Fluorocarbon
SPECIFIC GRAVITY	-	1.28	-
GRADE OF GREASE, NLGI	-	-	2.0
DROPPING POINT	-	> 232°C (> 450°F)	-
PENETRATION, at 25°C (77°F), Unworked, Min.	200	-	266.0
at 25°C (77°F), Worked, 10^5 Cycles	280 to 340	310	275.0
EVAPORATION, 22 hr. at 204°C (400°F), % Weight Loss, Max.	7.0	Passes	1.6
OIL SEPARATION, 30 hr. at 204°C (400°F), % Weight Loss, Max.	12.0	Passes	
COPPER CORROSION, 24 hr. at 100°C (212°F) (no green color)	Pass	Passes	Passes
LOW TEMPERATURE TORQUE (ball bearing) at -34°C (-30°F)			
Starting Torque, Max.	0.6867 N m. (7,000 g. cm.)	0.2943 N m. (3,000 g. cm.)	Passes
Running Torque, Max.	0.1962 N m. (2,000 g. cm.)	0.0491 N m. (500 g. cm.)	Passes
HIGH TEMPERATURE PERFORMANCE (ball bearing) Life at 204°C (400°F), hr. (min.)	400	> 750	> 2,000
EFFECT OF FUELS			
Solubility (1/2 hr. shaker), % Weight Loss, Max.	20.0	16.0	Passes
Resistance (8 hr. at 21°C (70°F), No Visible Effect (swelling, blistering or cracking)	Pass	Passes	Passes
RESISTANCE TO AQUEOUS SOLUTIONS (1.0 week at 21°C (70°F) Must Not Disintegrate or Dissolve in:			
(a) Distilled Water	Pass	Passes	Passes
(b) 50% Alcohol and Water	Pass	Passes	Passes
FILM STABILITY (1.0 week at 100°C (212°F)) No Deposit or Corrosion on Steel	Pass	Passes	Passes
STORAGE STABILITY (6.0 months)			
Unworked Penetration, Min.	200	Passes	Passes
Worked Penetration, Max.	± 30	Passes	Passes
DIELECTRIC BREAKDOWN VOLTAGE (kv.)	-	-	43.6
OXIDATION STABILITY, 600 hr. at 99°C (210°F), Pressure Drop			0

MILITARY SPECIFICATION: MIL-G-27617 (USAF)

GREASE, AIRCRAFT, FUEL AND OIL RESISTANT

PROPERTIES	SPEC. REQ.	FS-1292*	PR-240**
SHOCK SENSITIVITY, 95 N m. (70 ft/lb impact)			
Liquid Oxygen	No reaction	Passes	Passes
Nitrogen Tetroxide	-	-	No reaction
WEAR AND LOAD CARRYING CAPACITY			
Four-Ball Wear Test (2 hr. at 135°C (275°F), 1,200 rpm, 98 N (10 kg.) load)), Wear Scar, 10^{-3} m. (mm.)	-	0.60	-
Falex EP Test	-	9,786 N (2,000 lb.)	-
Mean Hertz Load	-	-	589 N (> 60 kg.)
USABLE TEMPERATURE RANGE, °F	-	-40°C to 204°C (-40°F to 400°F)	-34°C to 288°C (-30°F to 550°F)

* Dow Corning Corporation
** E. I. du Pont de Nemours & Company

NOTES: For a description and recommended usage of this series of chemically inert fluorosilicone base greases, see Section II.

MILITARY SPECIFICATION: MIL-G-46006 (MR)

GREASE, AIRCRAFT (HIGH TEMPERATURE, EXTREME PRESSURE)

PROPERTIES	SPEC. REQ.	EP2 952* MULTIFAK
COMPOSITION: Mineral Oil, %, Min.	79.0	Passes
Thickener, %, Min.	4.0	Passes
Additives, %	-	-
DROPPING POINT, Min.	177°C (350°F)	189°C (370°F)
PENETRATION: Unworked at 25°C (77°F)	-	295
Worked (60 cycles) at 25°C (77°F)	265-295	286
WORK STABILITY: 10^5 Cycles at 25°C (77°F), Worked Penetration Change, Max.	± 30	-
LOAD CAPACITY: (mean hertz load); Min.	314 N (32.0 kg.)	392 N (40.0 kg.)
CORROSIVENESS (No change in consistency. No green or dark brown color in grease. Copper strip shall show no evidence of green or black discoloration)	Pass	Passes
OXYGEN STABILITY: (bomb test); 100 hr. at 99°C (210°F), Pressure Drop, Max.	68,948 N/m^2 (10.0 psi)	27,579 N/m^2 (4.0 psi)
APPARENT VISCOSITY: 10^{-1} N sec/m^2 (poises), Max. at 25°C (77°F) and Shear Rate, 20 sec^{-1}	500	350
at 25°C (77°F) and Shear Rate, 50 sec^{-1}	300	170
OIL SEPARATION: 30 hr. at 100°C (212°F), % Wt. Loss, Max.	10.0	
PERFORMANCE TEST: (bearing life at 100,000 rpm, 149°C (300°F), and 22.2 N (5 lb.) load), Min. Life, Hr.	200	> 700
WATER RESISTANCE: 1.0 hr. at 38°C (100°F), % Wt. Loss, Max.	10.0	
GEAR WEAR TEST: (6,000 cycles at 71°C (160°F)); 22.2 N (5 lb.) Load; Brass Gear Wt. Loss, 10^{-6} kg/1,000 (Mg/1,000) Cycles	-	3.8
44.5 N (10 lb.) Load; Brass Gear Wt. Loss, 10^{-6} kg/1,000 (Mg/1,000) Cycles	-	6.4

* Texaco, Incorporated

NOTE: For a description and recommended usage of this high temperature, E.P., aircraft grease, see Section II.

MILITARY SPECIFICATION: MIL-G-81322 (WP)

GREASE, AIRCRAFT, GENERAL PURPOSE, WIDE-TEMPERATURE RANGE

PROPERTIES	SPEC. REQ.	XRR-38*
COMPOSITION: WIDE TEMP. LIQUID LUBRICANT	-	-
HIGH MELT POINT GELLING AGENT	-	-
ODOR: No Objectionable Odors	Pass	Passes
DROPPING POINT, Min.	260°C (500°F)	> 260°C (> 500°F)
PENETRATION: Worked at 25°C (77°F)	265-320	315
WORK STABILITY: 10^5 Cycles, Worked Penetration, Max.	375	337
COPPER CORROSION: 24 hr. at 100°C (212°F); (no green color, pit or etch)	Pass	Passes
OXIDATION STABILITY (bomb test); 500 hr. at 99°C (210°F) (pressure drop, max.)	172,400 N/m^2 (25.0 psi)	124,100 N/m^2 (18.0 psi)
EVAPORATION: 22 hr. at 177°C (350°F) % Weight Loss, Max.	10.0	1.9
OIL SEPARATION: 30 hr. at 177°C (350°F), % Weight Loss, Max.	10.0	4.2
WATER RESISTANCE: Bearing Washout, 1.0 hr. at 41°C (105°F) % Weight Loss, Max.	20.0	3.1
HIGH TEMPERATURE TEST at 177°C (350°F), Bearing Life, hr, Min.	400	> 500
LOW TEMPERATURE TORQUE at -54°C (-65°F) Starting Torque, Max.	0.981 N m. (10,000 g. cm.)	0.422 N m. (4,305 g. cm.)
Running Torque, Max.	0.0981 N m. (1,000 g. cm.)	0.0564 N m. (575 g. cm.)
LOAD CAPACITY: Mean Hertz Load, kg, Min.	294N (30.0 kg)	304N (31.0 kg)
RUBBER SWELL: 1.0 week at (158°F), "L" Syn. Rubber % Vol. Increase, Max.	15	6.3
WEAR SCAR, Steel-on-Steel, 2 hr. at 75°C (167°F), 1200 Rpm, 392N (40 kg), Load; Max. Scar Dia., 10^{-3} m. (mm.), (shell four ball)	1.30	0.63
RUST PREVENTIVE PROPERTIES: Bearing Test, 14 Days, at 24°C (77°F), 100% RH; Max. 3 Small Spots	Pass	Passes
STORAGE STABILITY: 6 Months at 38°C (100°F), Unworked Penetration	200 (Min.)	208
Worked Penetration	¹30 (Max.)	325

*Socony Mobil Oil Company

NOTE: For a description and recommended usage of this general purpose, aircraft greast, see Section II.

SYNTHETIC GREASE, ROCKET PROPELLANT COMPATIBLE

PERFLUOROTRIALKYLAMINE BASE FLUID, TETRAFLUOROETHYLENE POLYMER THICKENER

PROPERTIES	BRAYCOTE 617*
COLOR	Translucent white
COMPOSITION: Base Oil	Mixed perfluorotrialkylamines
Gelling Agent	Tetrafluoroethylene polymer
DENSITY: kg/10^{-3} m^3 (g/ml), at 16°C (60°F)	1.9
PENETRATION: (1/4 Scale)	265-310
EVAPORATION: 22 hr. at 99°C (210°F), % Wt. Loss	40-50
OIL SEPARATION: % Wt.	4.0
WATER RESISTANCE: at 38°C (100°F), % Wt. Loss	16.0
COPPER CORROSION (BOMB): 20 hr. at 99°C (210°F)	
Discoloration of Grease	None
Discoloration of Copper	None
Pressure Drop	0
WEAR TEST: Shell Four-Ball, 1 hr. at 600 rpm	
98.1 N (10 kg.) Load, Scar Dia., 10^{-3} m. (mm.)	0.26
372.4 N (40 kg.) Load, Scar Dia., 10^{-3} m. (mm.)	0.51
EXTREME PRESSURE: Shell Four-Ball (Weld)	2,453 N (250 kg.)
STATIC SERVICE TEST: Liquid Oxygen	Passes
Nitrogen Tetroxide	Passes
50:50 Blend, Hydrazine and Monomethyl Hydrozine	Passes
IMMERSION IN FUELS AND OXIDIZERS: 72 hr. at 25°C (77°F) (Change in Appearance)	
Ethanol (Etoh); Jet Fuel (JP-4); Aniline;	None
Diethylenetriamine (Deta); 60:40 UDMH; Deta;	None
50:50 UDMH; N_2H_4; Hydrogen Peroxide, 90%, H_2O_2;	None
Inhibited Red Fuming Nitric Acid (IRENA);	None
Nitrogen Tetroxide (N_2O_4)	None
IMPACT COMPATIBILITY (ABMA Tester)	
Liquid Oxygen; LOX	Passes
Nitrogen Tetroxide, N_2O_4	Passes
CONTACT COMPATIBILITY: Most Elastomers	Passes
Aluminum (Freshly Cut)	Passes

* Bray Oil Company

NOTE: Braycote 617 is a smooth, buttery, wholly synthetic grease which contains no hydrogen and withstands direct exposure under static conditions to most oxidizers and fuels currently used in rocket motors. Dynamic applications of Braycote 617, immersed in propellants, or at extreme temperatures, have not been fully determined. The base fluid is both volatile at elevated temperatures and soluble to varying degrees in N_2O_4 depending on temperature. Braycote 617 has lubricant antiwear and extreme pressure characteristics comparable to most conventional petroleum and synthetic greases. Braycote 617 is manufactured exactly in accordance with Formulation PD-817 by the method developed at Frankford Arsenal.

HIGH TEMPERATURE SYNTHETIC GREASE

NONMELTING GREASE, SILICONE BASE OIL (LEHIGH COMPANY)

PROPERTIES	ANDEROL L-758
COMPOSITION: Oil Base	Silicone
Thickener	Nonmelting
FLASH POINT	293°C (560°F)
FIRE POINT	316°C (600°F)
DROPPING POINT	> 260°C (> 500°F)
USABLE TEMPERATURE RANGE	-29°C to 343°C (-20°F to 650°F)
EVAPORATION: 22 hr. at 260°C (500°F), % Wt. Loss	2.0
VISCOSITY, 10^{-6} m^2/sec (Cs.) at 204°C (400°F)	4.6
at 99°C (210°F)	16.19
at 38°C (100°F)	63.19
SPECIFIC GRAVITY	1.07
PENETRATION: Unworked at 25°C (77°F)	220
Worked at 25°C (77°F)	270
STABILITY (Storage); (6 months at 38°C (100°F)) Unworked Peneration	260
OXIDATION: (Norma-Hoffman Bomb) 100 hr. at 99°C (210°F), Pressure Drop	< 5
HUMIDITY CABINET: 25°C ((77°F) at 50% RH); Hours	> 100
CORROSION: Copper Strip; 24 hr. at 100°C (212°F)	Passes
Copper-Brass; 24 hr. at 100°C (212°F)	Passes

NOTE: Anderol L-758 is a nonmelting synthetic grease with a silicone base oil. A small percentage of MoS_2 is added to increase lubricity. Usable temperature range of -29°C to 343°C (-20°F to 650°F). Recommended for high temperature conveyors, plastic extruding machines, couplings, cams and followers.

HIGH TEMPERATURE SYNTHETIC GREASE DIESTER BASE FLUID

(LEHIGH CHEMICAL COMPANY)

PROPERTIES	ANDEROL L-762
SPECIFIC GRAVITY	0.93
FLASH POINT	26-°C (500°F)
FIRE POINT	285°C (545°F)
DROPPING POINT	> 260°C (> 500°F)
POUR POINT	-62°C (-80°F)
USABLE TEMPERATURE RANGE	-40°C to 260°C (-40°F to 500°F)
VISCOSITY, 10^{-6} m^2/sec (Cs.) at 99°C (210°F)	6.7
at 38°C (100°F)	37.9
at -18°C (0°F)	1,400
EVAPORATION: 22 hr. at 204°C (400°F); % Wt. Loss	< 5.0
OIL SEPARATION: 24 hr. at 25°C (77°F); % Wt. Loss	< 2.0
PENETRATION: Unworked at 25°C (77°F)	285
Worked at 25°C (77°F)	295
WORK STABILITY: 10^5 strokes at 25°C (77°F)	365
COPPER STRIP: 24 hr. at 100°C (212°F); (no etch or pits)	Passes
NORMA-HOFFMAN BOMB OXIDATION	
100 hr. 7.58 x 10^5 N/m^2 (110 psi) at 99°C (210°F); psi Drop.	0.0
500 hr. 7.58 x 10^5 N/m^2 (110 psi) at 99°C (210°F); psi Drop.	0.2

NOTES: Anderol L-762 is a medium consistency, nonmelting grease with Anderol L-826 medium heavy diester base oil. It is a noncarboning grease that forms no gum or sludge and has good thermal stability. Used for long life lubrication under medium to very heavy loading conditions. Recommended for gear boxes, conveyors, ovens, appliances, tools, high temperature conveyors and ovens.

"APIEZON" HIGH VACUUM GREASE (JAMES G. BIDDLE COMPANY)

PROPERTIES	GREASE AP 100	GREASE AP 101	GREASE H	GREASE L	GREASE M	GREASE N	GREASE T
APPROXIMATE MELTING POINT, °C	47	a/	a/	47	44	43	125
(°F)	(117)			(117)	(111)	(109)	(257)
SPECIFIC GRAVITY at 20°C/15.5°C (68°F/60°F)	1.042	0.981		0.896	0.894	0.911	0.912
30°C/15.5°C (86°F/60°F)	1.036	0.974		0.889	0.887	0.904	0.905
VISCOSITY, 10^{-3} N sec/m^2 (cP) of Molten Grease at 50°C (122°F)				0.766 (766)	0.413 (413)		
100°C (212°F)				0.0623 (62.3)	0.0298 (29.8)		
AVERAGE MOLECULAR WEIGHT				1,300	950		
COEFFICIENT OF EXPANSION, Over 20°C-30°C (68°F-86°F), per °C	0.00062	0.00066		0.00076	0.00075	0.00072	0.00073
°F	0.00034	0.00037		0.00042	0.00042	0.00040	0.00041
THERMAL CONDUCTIVITY Btu in/ft^2 h., °F			1.50	1.40	1.33	1.31	1.22
w/m, °C			0.216	0.202	0.192	0.189	0.176
SPECIFIC HEAT at 25°C (77°F), cal/g			0.42	b/	b/	b/	b/
Joule/g			1.7	b/	b/	b/	b/
LATENT HEAT OF FUSION, cal/g				15.1	18.7	15.0	
Fusion Peak, °C				32	34	31	
(°F)				(90)	(93)	(88)	
VOLUME RESISTIVITY, ohm cm.				1.2×10^{16}	2.6×10^{16}	2.0×10^{16}	3.3×10^{12}
PERMITTIVITY				2.3	2.1	2.3	2.3
LOSS TANGENT					Less than 0.0001		
SURFACE BREAKDOWN, kv. at flash-over				24	28	27	24
ELECTRIC STRENGTH, volts/mil				730	850	820	730
RECOMMENDED USABLE TEMP. RANGE, °C	10-30	-40-180	-10-240	10-30	10-30	10-30	0-120
(°F)	(50-86)	(-40-292)	(14-464)	(50-86)	(50-86)	(50-86)	(32-248)

a/ Greases AP 101 and H do not melt at high temperatures and consequently many of the above physical properties cannot readily be measured.

b/ Specific heats of Greases L, M, N, and T cannot be measured as their fusion peaks are too close to room temperature.

NOTES: 1. These low vapor pressure greases are used largely as vacuum greases, but because of their high purity they are also excellent laboratory greases. Most "Apiezon" greases are expensive but Grease M is competitive with the best general purpose laboratory lubricants and is a general purpose grease with excellent lubricating properties as well as a high vacuum grease.

2. These greases are also used with the liquid medium in gas-liquid chromatography.

SYNTHETIC SILICA-FILLED GREASE (LIMITED LOX SENSITIVITY)

FLUOROSILICONE FLUID - DOW CORNING

PROPERTIES	DOW CORNING (FS-1281)
COMPOSITION: Fluid	Fluorosilicone
Thickener	Silica filler
COLOR	Opaque-white
SPECIFIC GRAVITY, at 25°C (77°F)	1.24
DROPPING POINT	> 260°C (> 500°F)
USEABLE TEMPERATURE RANGE	-62°C to 204°C (-80°F to 400°F)
PENETRATION: (ASTM D-217); Unworked at 25°C (77°F)	180-220
Worked (60 Cycles) at 25°C (77°F)	300
BLEED TESTS: 24 hr, at 199°C (390°F), % Wt. Loss	7.0
EVAPORATION TEST: 24 hr, at 199°C (390°F), % Wt. Loss	2.0
WATER ABSORPTION: 24 hr. at 100% RH; % Wt. Loss	Nil
FALEX TEST: Steel-on-Steel	4,448.2 N (1,000 lb)
LOX RESISTANCE: ("ABMA" 97.6 N m. (72 ft/lb) Impact Test))	Significant insensitivity
TOXICITY TEST; Temperature Range < 288°C (<550°F)	None
> 288°C (>550°F)	Toxic
SOLUBILITY TEST: (8 hr), % Wt. Loss, JP-4 Fuel	12.0
Kerosene	16.0
Gasoline	32.0
Water	1.0
Methyl Ethyl Ketone	99.0
Other Petroleum Base Solvents	6.0 - 80.0
OXIDIZER AND FLUID RESISTANCE: 8.0 hr, 30% Hydrogen Peroxide	No effect
Ethylene Glycol	No effect
Glycerol	No effect
Diethylene Triamine	Slight
IRF Nitric Acid (Rocket Fuel)	Slight
Hydrochloric Acid (10%)	Slight
Hydrochloric Acid Conct.	Moderate
Sodium Hydroxide, 10%	Moderate - Fair
Unsymmetrical Dimethyl Hydrazine	Poor
LOW TEMPERATURE TORQUE (Running Torque), g. cm. -34°C (-30°F)	< 0.0981 N m. (< 1,000 g. cm)
-54°C (-65°F)	0.0981 N m. (1,000 g. cm.)
-62°C (-80°F)	0.1962 N m. (2,000 g. cm.)

SYNTHETIC SILICA-FILLED GREASE (LIMITED LOX SENSITIVITY)

FLUOROSILICONE FLUID - DOW CORNING

PROPERTIES	DOW CORNING (FS-1281)		
EFFECT ON ELASTOMERS: 7 Days at 70°C (158°F)			
	Change In Shore Duometer	Change In Volume, %	Change In Wt., %
Silastic; LS-53 Rubber	-10	+10.6	+8.0
Silastic; 50 Rubber	-6	+4.6	+2.9
Viton 77-515	-4	+1.2	-0.1
Neoprene 37-043	+2	-4.4	-5.3
GRS 37-076 (Rubber)	4	-0.9	-2.1
Butyl 37-024	-3	-0.3	-0.4
MIL-P-5315A Type (Rubber)	+6	-7.4	-6.2

NOTE: FS-1281 compound is a grease-like compound composed of a fluorosilicone fluid thickened with finely divided silica filler; insoluble in most oils, fuels, and solvents; little or no attack on most rubber seals; good lubricity properties; and is nontoxic below 288°C (550°F).

Recommended uses: This compound is recommended as a fuel, oil, and solvent-resistant value lubricant, for application of extreme temperature range, and for lubricating low-speed bearings.

HYDROCARBON SYNTHETIC GREASES

(HALOCARBON PRODUCTS CORPORATION)

PROPERTIES	STANDARD STOPCOCK GREASE	HIGH-TEMP. STOPCOCK GREASE	25-10	25-10M	25-10M-SA	25-20M
COMPOSITION						
Halocarbon Oil	Yes	Yes	Yes	Yes	Yes	Yes
Polychlorotrifluoro-ethylene Wax	Yes	Yes	Yes	Yes	Yes	Yes
Silica Gel	-	-	-	-	-	-
Rust Inhibitor	-	-	-	-	Yes	-
Milled	-	-	-	Yes	Yes	Yes
COLOR	White	White	White	White	Brown	White
DROP POINT, Min.						
°C	149	149	149	149	149	160
°F	300	300	300	300	300	320
USABLE TEMPERATURE RANGE						
°C	16-60	29-104	1-135	1-135	1-121	1-149
°F	60-140	85-220	30-275	30-275	30-250	30-300
FLUID RANGE						
°C	149-260	149-260	149-260	149-260	-	160-260
°F	300-500	300-500	300-500	300-500	-	320-500
MEAN HERTZ LOAD, kg.	-	-	104.4	104.4	-	106.6
PENETRATION, Unworked	115	70	170	190	230	170
(ASTM-D217), Worked	345	320	290	315	350	275

POLYCHLOROTRIFLUOROETHYLENE AND SILICA GEL GREASES

PROPERTIES	25-20M-5A	X90-10M	X90-15M	25-5S	11B3
COMPOSITION					
Halocarbon Oil	Yes	Yes	Yes	Yes	Yes
Polychlorotrifluoroethylene Wax	Yes	Yes	Yes	-	-
Silica Gel	-	-	-	Yes	Yes
Rust Inhibitor	Yes	-	-	-	-
Milled	Yes	Yes	Yes	-	-
COLOR	Brown	White	White	White	White
DROP POINT					
°C	149	149	146	None	None
°F	300	300	295	None	None
USABLE TEMPERATURE RANGE					
°C	1-121	-40 to 93	-40 to 93		-40 to 93
°F	30-250	-40 to 200	-40 to 200	0-350	-40 to 200
FLUID RANGE					
°C	-	149-260	149-260	None	None
°F	-	300-500	300-500	None	None
MEAN HERTZ LOAD, kg.	-	-	94.4	100.0	97.2
PENETRATION, Unworked	240	260	260	230	230
Worked	285	300	265	230	230

NOTES:
1. Halocarbon greases are noncorrosive toward metals at temperatures up to 177°C (350°F), except for copper and some of its alloys which discolor at 49°C (120°F). These greases are not recommended for aluminum applications where localized temperatures and stresses of minute seizure may result in detonation.
2. Halocarbon greases may be used with most elastomers and solvent-resistant plastics at room temperatures. For elevated temperatures it is recommended that tests be conducted at anticipated temperatures and pressures.
3. These greases are chemically inert, have light thermal stability, good lubricity, high dielectric strength and density.

HIGH TEMPERATURE, HIGH VACUUM GREASE
OXIDIZER AND FUEL RESISTANT (BRAY OIL COMPANY)

PROPERTIES	MICRONIC® 803
COMPOSITION: Base Stock Oil Thickener - Gelling Agent	Pefluoroalkyl polyether (High Mol. Wt.) Tetrafluoroethylene telomer
FLASH/FIRE POINT	None; Nonflammable
DROPPING POINT	253°C (488°F)
USABLE TEMPERATURE RANGE; Air Inert Atmosphere	-23°C to > 260°C (-10°F to > 500°F) -23°C to 300°C (-10°F to 680°F)
VOLATILITY: 240°C (400°F), 22 hr; Weight Loss %	None < 1.8
VISCOSITY	-
SPECIFIC GRAVITY	-
PENETRATION: at 25°C (77°F)	296-313
OIL SEPARATION: 204°C (400°F), 30 hr.; %	93-15.7
OXIDIZER RESISTANCE Impact Test: MSFC-Spec.-101 MSFC-Spec.-106B	Resistant to All Oxidizers Passes Passes
FUEL AND REDUCER RESISTANCE	No Reaction
SOLUBILITY AND WASH-OUT RESISTANCE	Insoluble in most fluids, soluble only in highly fluorinated liquids
LUBRICATING ABILITY:	Excellent E.P. Properties
WEAR PREVENTION: 4-Ball Test, 8 hr. at 60°C (140°F), and 600 rpm, Scar Dia. in mm. Load-Max. Hertz Stress; 1.214×10^9 N/m^2 (176,000 psi) 3.654×10^9 N/m^2 (530,000 psi)	 0.398 1.199
VACUUM PROPERTIES	Excellent
VACUUM WEIGHT LOSS; % 46 hr, at 121°C (250°F) and 1.33×10^{-5} N/m^2 (10^{-7} torr)	Nil

LOW-VOLATILITY SYNTHETIC GREASE;

FOR AIR, VACUUM AND SPACE APPLICATIONS (BALL BROTHERS RESEARCH CORPORATION)

PROPERTIES	VAC KOTE 36209
MILITARY SPECIFICATION	None
COLOR	Very light amber
COMPOSITION, Base Oil	Synthetic
Thickner	Nonmelting
Additives	E.P., oxid./corrosion inhibitor
DROPPING POINT	> 204°C (> 400°F)
USABLE TEMPERATURE RANGE	
Low	-46°C (-50°F)
High	121°C (250°F)
PENETRATION, Worked at 24°C (77°F)	290
WEAR RESISTANT (EP)	Good
SHELL FOUR-BALL WEAR TEST at 200°C (392°F) (90 mm., 600 rpm, 98.07 N (10 kg.)), Average Scar Diameter, mm.	0.312
OXIDATION RESISTANT	Good
STORAGE STABILITY	Good
COMPATIBILITY WITH:	
Rubber, Neoprene, Plastics	No
Paints, Lacquer, Solvents	No
Jet Fuel & Gasoline	No
Rocket Fuel	No
"LOX"	No
VACUUM PROPERTIES	Good
RECOMMENDED USES:	
Electrical Equipment	Good
Instrument	Good
Ball and Roller Bearings	Good
Plan Bearings	Good
Sliding Surfaces	Good
Gears	Good

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HIGH TEMPERATURE SYNTHETIC GREASES

KRYTOX® FLUORINATED GREASES (E. I. du Pont de Nemours & Company)

PROPERTIES	KRYTOX® 240 AC	KRYTOX® 250 AC	KRYTOX® 260 AC	KRYTOX® 280 AC
COMPOSITION	KRYTOX® 143 AC oil with VYDAX® fluorotelomer solids	KRYTOX® 240 AC and MoS_2	KRYTOX® 240 AC plus rust inhibitor and MoS_2	KRYTOX® 240 AC plus rust inhibitor
VISCOSITY OF BASE FLUID, 10^{-6} m^2/sec (Cs.) at 38°C (100°F)	270	270	270	270
COLOR	White	Black	Black	White
TEXTURE	Buttery	Buttery	Buttery	Buttery
DENSITY, kg/10^{-3} m^3 (g/ml) at 25°C (77°F)	1.93	2.02	2.03	1.95
PENETRATION (ASTM D217) mm/10 at 25°C (77°F)				
Unworked	274	242	243	244
Worked 60 Strokes	282	249	250	253
MECHANICAL STABILITY				
Penetration After 100,000 Strokes	312	292	285	294
Penetration After 2-Hr. Shell Roll Test (ASTM D1831)	-	276	269	284
EVAPORATION, FTMS 791-351, Weight %				
at 149°C (300°F) for 22 hr.	...			
at 204°C (400°F) for 22 hr.	2			
at 260°C (500°F) for 22 hr.	3			
OIL SEPARATION, FTMS 791-321,				
Weight % After 30 hr. at 99°C (210°F)	3	5	4	5
Weight % After 30 hr. at 204°C (400°F)	11	13	6	14
WATER RESISTANCE, FTMS 791-3252, Weight % Loss at 79°C (175°F)	1	1	1	1
LOAD CARRYING CAPACITY, ASTM D-2596				
Load Wear Index, kg.	78	86	95	88
Weld Point, kg.	400	400	>800	800
WEAR PREVENTION (ASTM D-2266) Shell 4-Ball-40 kg. Load, 1-hr. and 120 rpm.				
Wear Scar at 75°C (167°F), mm.	1.88	1.69	-	-
Wear Scar at 204°C (400°F), mm.	1.02	1.13	-	-
OXIDATION STABILITY, ASTM D942, Psig Oxygen. Pressure Drop in 600 hr. at 99°C (210°F)	0	0		0
LIQUID OXYGEN IMPACT TESTS				
USAF Spec. Bulletin 527	Pass	-	-	-
NASA MSFC Spec. 106	Pass	Pass	Pass	Pass
Southwest Research Institute Reaction Intensity	Pass	-	-	-

KRYTOX® FLUORINATED GREASES (E. I. du Pont de Nemours & Company)

PROPERTIES	RUST INHIBITOR PL-883	5% MoS_2 PLUS RUST INHIBITOR PL-884	5% MoS_2 PL-885
COMPOSITION	Same as KRYTOX® 280 AC but has more rust inhibitor	More rust inhibitor than in KRYTOX® 260 AC, microsize MoS_2	Contains microsize MoS_2
VISCOSITY OF BASE FLUID, 10^{-6} m^2/sec (Cs.) at 38°C (100°F)	270	270	270
COLOR	White	Black	Black
TEXTURE	Buttery	Buttery	Buttery
DENSITY, kg/10^{-3} m^3 (g/ml) at 25°C (77°F)	1.97	2.02	2.00
PENETRATION (ASTM D217) mm/10 at 25°C (77°F)			
Unworked	241	230	246
Worked 60 strokes	229	225	244
MECHANICAL STABILITY			
Penetration After 100,000 Strokes	-	-	-
Penetration After 2-hr. Shell Roll Test (ASTM D1831)	270	248	272
OIL SEPARATION, FTMS 791-321			
Weight % After 30 hr. at 99°C (210°F)	4	2	4
Weight % After 30 hr. at 204°C (400°F)	15	8	12
WATER RESISTANCE, FTMS 791-3252, Weight % Loss at 79°C (175°F)	1	1	1
LOAD CARRYING CAPACITY, ASTM D-2596			
Load Wear Index, kg.	89	90	86
Weld Point, kg.	> 800	> 800	500
WEAR PREVENTION (ASTM D-2266) Shell 4-Ball-40 kg. load, 1 hr. and 120 rpm.			
Wear Scar at 75°C (167°F), mm.	0.97	1.74	0.67
Wear Scar at 204°C (400°F), mm.	1.06	1.20	0.69
LIQUID OXYGEN IMPACT TESTS			
USAF Spec. Bulletin 527			
NASA MSFC Spec. 106	Pass		Pass
Southwest Research Institute Reaction Intensity			

NOTE: 1. KRYTOX® fluorinated greases are multipurpose lubricants with superior high-temperature stability, chemical inertness and solvent resistance and usually good lubricity properties. They are ideal in many industrial applications where long service life is not possible with other available lubricants. KRYTOX® greases are extensively used to lubricate aircraft components, missiles, space vehicles, and attendant ground support equipment.

2. KRYTOX® greases are prepared by thickening KRYTOX® fluorinated oils with VYDAX® fluorotelomer solids. These greases have similar chemical and compatibility characteristics as the base oils from which they are made, see III-59, 71 and 72.

3. These greases have a usable temperature range from -34°C to 288°C (-30°F to 550°F).

FEDERAL SPECIFICATION: VV-P-236

PETROLATUM, TECHNICAL

PROPERTIES	SPEC. REQ.	BRAYCOTE* 236	PARMO** 70	ROYCO*** IR
COLOR, ASTM	2 to 8	L7.5	L2.5	Amber
MELTING POINT	46°C to 60°C (115°F to 140°F)	49°C (120°F)	54°C (130°F)	46°C to 60°C (115°F to 140°F)
FLASH POINT, COC, Min.	199°C (390°F)	246°C (475°F)	218°C (425°F)	199°C (390°F)
VISCOSITY, at 99°C (210°F), Sus.	70 to 95	79.5	77	70 to 95
PENETRATION (unworked), 10^{-4} m. (0.1 mm.)	150 to 275	218		150 to 275
CORROSION ON COPPER, 24 hr. at 100°C (212°F)	None	None	None	None
ASH CONTENT, % Max.	0.1	0.027	-	< 0.1
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg/KOH/g, max.)	0.1	0.0		
PRECIPITATION NUMBER, Max.	0.1	0.0	-	< 0.1
ABRASIVE MATERIAL	None	None	None	None
EVAPORATION LOSS, 1.0 hr. at 107°C (225°F), % Weight	2.0	0.48	Nil	< 2.0
CONSISTENCY	-	Soft	Soft	Soft
TRANSLUCENT	-	Yes	Yes	Yes
USABLE LOAD RANGE		Low	-	Low
USABLE TEMPERATURE		Cool		Cool

* Bray Oil Company
** Humble Oil & Refining Company
*** Royal Lubricants Company

NOTES: For a description of this light grade technical petrolatum grease and recommended usage, see Section II.

THREAD COMPOUND, ANTISEIZE AND SEALING, OXYGEN

PROPERTIES	SPEC. REQ.	DAG* 217	RECTORSEAL** No. 15
COMPOSITION (smooth, no lumps)	Req.	Passes	Passes
Mineral or Vegetable Oils	None	None	None
Animal Oils or Fats	None	None	None
Materials Inflammable with Oxygen, 13.79×10^6 N/m^2 (2,000 psi)	None	None	None
COLOR	-	-	-
ODOR (nonobjectionable)	Req.	None	None
TOXICITY (no skin irritants or sensitizers)	Req.	Passes	Passes
ANTISEIZE, None on Std. Thd. Fittings at 13.79×10^6 N/m^2 (2,000 psi)	Req.	Passes	Passes
SEALING, No Leaks on Std. Thd. Fittings at 13.79×10^6 N/m^2 (2,000 psi)	Req.	Passes	Passes
USABLE TEMPERATURE RANGE	-54°C to 71°C (-65°F to +160°F)	-54°C to 71°C (-65°F to +160°F)	-54°C to 100°C (-65°F to +212°F)
VIBRATION TEST, Thd. Fitting, 24 hr. at 13.79×10^6 N/m^2 (2,000 psi)	No leak	Passes	Passes
CORROSION, Aluminum, Steel, and Brass, 48 hr.	None	None	None
FLAMMABILITY TEST (nonsupport flame)	Req.	Passes	Passes
BOMB OXIDATION PROPERTIES			
Oxygen, 1.0 hr. at 13.79 x 10^6 N/m (2,000 psi) and 150°C (302°F)	No change	Passes	Passes
Oxygen Surge Pressure, 13.79×10^6 N/m^2 (2,000 psi) at 150°C (302°F)	No reaction	Passes	Passes
FLUID TYPE	-	Organic	Organic
SOLID PARTICLES	-	Graphite	Graphite
SOLID CONTENT, %	-	24	-
PARTICLE SIZE	-	C	-
DENSITY	-	1,605 kg/m^3 (13.4 lb/gal)	1,725 kg/m^3 (14.4 lb/gal)
SPECIFIC GRAVITY	-	-	1.729
FLASH POINT	-	-	None
PENETRATION VALUE, at 25°C (77°F) (ASTM)			300

* Acheson Colloids Company
** Rector Well Equipment Company, Inc.

NOTE: For a description and recommended usage of this light grease or paste antiseize and sealing compound, compatible with gaseous oxygen, see Section II.

MILITARY SPECIFICATION: MIL-T-5544B

THREAD COMPOUND, ANTISEIZE, GRAPHITE-PETROLATUM

PROPERTIES	SPEC. REQ.	ESSO* AVIATION ANTI-SEIZE COMP. 1	ROYCO** 44
COLOR	-	Grey	Black
COMPOSITION: PETROLATUM, %	48 - 52	Passes	Passes
GRAPHITE, %	52 - 48	Passes	Passes
PETROLATUM: TYPE (spec.)	VV-P-236	Passes	Passes
GRAPHITE (spec.)	SS-G-659	Passes	Passes
Particles on 148 x 10^{-6} m. (100 mesh) Screen, %	None	Passes	Passes
Particles on 79 x 10^{-6} m. (200 mesh) Screen, %	< 2.0	Passes	Passes
PENETRATION: 25°C (77°F), Worked (cone)	170 - 260	200	Passes
STABILITY: (centrifuge, 1/2 hr. at 1500 rpm) (separation)	None	None	None
TEMPERATURE RANGE, Max.	-	-	649°C (1200°F)
ELECTRICAL CONDUCTOR		Yes	Yes
COMPATIBLE WITH OXYGEN		No	No
COMPATIBLE WITH GASOLINE OR OIL		No	No

* Humble Oil & Refining Company
** Royal Lubricants Company

NOTES: For a description and recommended usage of this high temperature graphite-base antiseize thread compound, see Section II.

In addition to the products listed the antiseize compounds shown below supplied by the listed manufacturers also meet the requirements of this specification:

Product Name	Manufacturer
Braycote 655	Bray Oil Company

MILITARY SPECIFICATION: MIL-C-11796B CLASS (1 & 1A HARD FILM)

CORROSION PREVENTIVE COMPOUND, PETROLATUM, HOT APPLICATIONS

PROPERTIES	SPEC. REQ.	BRAYCOTE 202*	COSMOLINE 1060**
PENETRATION, 10^{-4} m. (tenths of millimeter)	30-80	38	30-80
MELTING POINT (min.)	68°C (155°F)	78°C (172°F)	68°C (155°F)
FLASH POINT (min.)	177°C (350°F)	279°C (535°F)	177°C (350°F)
STABILITY (cycled between 107°C (225°F) and -40°C (-40°F)	No foaming, separation	Passes	Passes
VOLATILITY, % Wt. (3 hr. at 107°C (225°F)	1.0 Max.	0.12	Passes
ABRASIVES	None	Passes	Passes
CORROSION PROTECTION (weatherometer, hours to rust)	300 (min.)	Passes	Passes
(outdoor exposure, years to rust)	1 (min.)	Passes	Passes
REMOVABILITY (after weatherometer, cycles)	15 (max.)	6	-
(after outdoor exposure, cycles)	150 (max.)	120	-
FLOW POINT, Min.	66°C (150°F)	Passes	No flow at 66°C (150°F)
LOW TEMPERATURE, Cut While at -40°C (-40°F)	No flaking	Passes	Passes
CORROSIVENESS, 14 Days at 82°C (180°F) Pitting or Etching	None	Passes	Passes
WEIGHT CHANGE, 10^{-10} kg/m^2 (mg/cm^2)			
Aluminum	± 0.2	+0.04	None
Brass	± 0.2	-0.01	None
Cadmium	± 0.2	+0.02	None
Magnesium	± 0.5	+0.07	None
Steel	± 0.2	-0.01	None
Zinc	± 0.2	+0.03	None

* Bray Oil Company
** E. F. Houghton & Company

NOTES: For a description of this material and recommended usage, see Section II.

Other companies supplying material to this specification include:

Product	Manufacturer
H-2, H-10	Franklin Oil Corporation
4024 Rust Preventive	Humble Oil and Refining Company
Kendex 7010	Kendall Refining Company
NOX-Rust 507	NOX-Rust
Petrotect P-50	Pennsylvania Refining Company
Tectyl 435	Valvoline Oil Company

Materials are also available conforming to Classes 2 and 3 of this specification. Class 2 is a hot application medium film and Class 3 is either hot or cold application soft film. These materials are generally available from the same suppliers of Class 1 and 1A materials.

MILITARY SPECIFICATION: MIL-S-8660B

SILICONE COMPOUNDS

PROPERTIES	SPEC. REQ.	DOW CORNING 4* COMPOUND	INSUL GREASE** G-624
COLOR (grey or cream, color dye permitted)	Note	Light grey	Light grey
PENETRATION, Unworked at 25°C (77°F)	200 to 260	200	200 to 260
Worked at 25°C (77°F), Max.	310	240	< 310
Worked at 25°C (77°F) (24 hr. at 204°C (400°F), Max.	310	Passes	-
CORROSIVE PROPERTIES (70 hr. at 100°C (212°F) Metals:			
Aluminum Alloy, Copper, Lead, Magnesium Alloy, Solder, Zinc and Cadmium-plated Steel; Singly and Coupled	No pit or etch	Passes	
Nonmetals: Natural or Synthetic Rubber, Phenol Formaldehyde Resin, Urea Formaldehyde Resin, Co-polymer of Vinyl Chloride and Vinyl Acetate Resin	No change	Passes	
RUBBER SWELL, 168 hr. at 70°C (158°F), % Volume	± 7.0	-	
INSOLUBILITY, 7 Days at 25°C (77°F), % Weight Loss			
Distilled Water, %	0.4	-	-
Isopropyl Alcohol (91%), %	10.0	-	-
Ethyl Alcohol, %	7.0	-	-
Ethylene Glycol, %	0.5	-	-
Glycerine, %	0.5	-	-
WATERPROOF SEAL TEST, 24 hr. at 25°C (77°F)	Pass	Passes	-
TOXICITY	None	None	-
FLAMMABILITY TEST (nonflammable)	Pass	-	-
HIGH TEMPERATURE EVAPORATION, 30 hr. at 204°C (400°F), % Weight Loss (max.)	2.0	1.5	< 2.0
HIGH TEMPERATURE BLEED, 30 hr. at 204°C (400°F), % Weight Loss	8.6	4.0	< 8.0
LOW TEMPERATURE TORQUE, ASTM D-1478, -54°C (-65°F), Max.			
Starting Torque	0.491 N m. (5,000 g. cm.)	Passes	-
Running Torque	0.0981 N m. (1,000 g. cm.)	Passes	-
STORAGE STABILITY, 6 Months at 38°C (100°F), Penetration Changes	None	-	
ARC Resistance (Method 4011, Fed. Std. 406), Time, Sec.	60	100	> 100

SILICONE COMPOUNDS

PROPERTIES	SPEC. REQ.	DOW CORNING 4* COMPOUND	INSUL GREASE*** G-624
DIELECTRIC STRENGTH (Method 4031, Fed. Std. 406)			
1.27×10^{-6} m. (0.050 in.), Electrode Gap (min.)	11.8×10^{6} volts/m (300 volts/mil)	11.8×10^{6} volts/m (300 volts/mil)	11.8×10^{6} volts/m (300 volts/mil)
0.254×10^{-6} m. (0.010 in.), Electrode Gap (min.)	19.7×10^{6} volts/m (500 volts/mil)	- -	19.7×10^{6} volts/m (500 volts/mil)
DIELECTRIC CONSTANT AND DISSIPATION FACTOR (Method 4021, Fed. Std. 406), 23°C (73.4°F), 50% RH			
Dielectric Constant, at 1.0 kc., 1 & 10 Megacycles	2.90 (max.)	2.85	< 2.90
Dissipation Factor, at 1.0 kc., 1 & 10 Megacycles	0.0025 (max.)	0.0006	< 0.0025
ELECTRICAL RESISTANCE (volume),			
24 hr. at 23°C (73.4°F), Ohms, 10^{-2} m. (cm.) (min.)	1.0×10^{13}	1.0×10^{14}	1.0×10^{13}
4 hr. at 177°C (350°F), Ohms, 10^{-2} m. (cm.) (min.)	1.0×10^{12}	1.0×10^{12}	-
USABLE TEMPERATURE RANGE	-	-57°C to 204°C (-70°F to +400°F)	-54°C to 204°C (-65°F to +400°F)
SPECIFIC GRAVITY		-	1.03

* Dow Corning
** General Electric, Silicone Products Department

NOTES: For a description and recommended usage of this greaselike silicone compound, see Section II.

In addition to the products listed, silicone compound "Y2900," manufactured by Union Carbide Corporation, Silicone Division, also meets the requirements of this specification.

HYDRAULIC FLUID, PETROLEUM BASE; AIRCRAFT, MISSILE, ORDNANCE

PROPERTIES	SPEC. REQ.	ROYCO* MICRONIC 756 A&B	BRAYCO** MICRONIC 756 D	HYDRAULIC OIL AA***
POUR POINT (max.)	-59°C (-75°F)	< -65°C (<-85°F)	< -65°C (< -85°F)	< -59°C (< -75°F)
FLASH POINT (min.)	93°C (200°F)	102°C (215°F)	102°C (215°F)	102°C (215°F)
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g) (max.)	0.20	0.07	0.07	0.03
VISCOSITY, 10^{-6} m^2/sec (Cs.)				
at 54°C (130°F) (min.)	10	10.16	10.16	10.3
at -40°C (-40°F) (max.)	500	473	473	475
at -54°C (-65°F) (max.)	3,000	2,127	2,127	-
CORROSION AND OXIDATION STABILITY, 121°C (250°F) for 168 hr.				
Weight Change, 10^{-10} kg/m^2 (mg/cm^2) Steel	± 0.2	-0.02	-0.02	Passes
Aluminum Alloy	± 0.2	0.00	0.00	Passes
Magnesium	± 0.2	-0.01	-0.01	Passes
Cadmium Plated Steel	± 0.2	-0.04	-0.04	Passes
Copper	± 0.6	-0.03	-0.03	Passes
No Pitting or Etching at 20X	Passes	Passes	Passes	Passes
Corrosion (ASTM Copper Corr. Std.), Max.	3	Passes	Passes	Passes
Viscosity Change, 54°C (130°F), %	-5 to +20	+4	+4	Passes
Neutralization Number, Increase, 10^{-3} kg. KOH/kg (mg. KOH/g)	± 0.20	0.04	0.04	Passes
LOW TEMPERATURE STABILITY, 72 hr. at -54°C (-65°F)	No solids or separation	Passes	Passes	Passes
SHEAR STABILITY, Viscosity Decrease, %,				
at 54°C (130°F)	Less than	Passes	Passes	Passes
at -40°C (-40°F)	Ref. fluid	Passes	Passes	Passes
Neutralization Number Change (max.)	+0.20	Passes	Passes	Passes
RUBBER SWELL, Type "L", % Volume Change	+19.0 to 28.0	26.2	26.2	22.4
EVAPORATION, 4 hr. at 66°C (150°F) Oily, Not Hard or Tacky	Pass	Passes	Passes	Passes
COPPER STRIP CORROSION (ASTM Copper Corr. Std.), Max.	2	1	1	1a

MILITARY SPECIFICATION: MIL-H-5606B

HYDRAULIC FLUID, PETROLEUM BASE; AIRCRAFT, MISSILE, ORDNANCE

PROPERTIES	SPEC. REQ.	ROYCO* MICRONIC 756 A&B	BRAYCO** MICRONIC 756 D	HYDRAULIC OIL AA***
SOLID PARTICLE CONTAMINATION, No. Parts, 10^{-4} m^3 (No. particles/100 ml.) (max.)				
5-15 x 10^{-6} m. (microns)	2,500	460	466	-
16-25 x 10^{-6} m. (microns)	1,000	87	87	-
26-50 x 10^{-6} m. (microns)	250	29	29	-
51-100 x 10^{-6} m. (microns)	25	9	9	-
Over 100 x 10^{-6} m. (microns)	None	0.65	0.65	-
FOAMING, at 24°C (75°F) After				
5 Min. Blowing, 10^{-6} m^3 (ml.)	65	55	55	-
10 Min. Settling, 10^{-6} m^3 (ml.)	0	0	0	-
WATER CONTENT, %	0.01	0.004	0.004	-
STORAGE STABILITY	Pass	-	-	-
ADDITIVES:				
Viscosity-Temperature Coefficient Improvers	Yes	Yes	Yes	-
Oxidation Inhibitors	Yes	Yes	Yes	Yes
Antiwear (tricresyl phosphate)	Yes	Yes	Yes	Yes

* Royal Lubricants Company
** Bray Oil Company
*** Texaco, Incorporated

NOTES: For a description of this hydraulic fluid and recommended usage, see Section II.

In addition to the products listed, the hydraulic fluids supplied by the following manufacturers also meet the general requirements of this specification.

Product Name	Manufacturer
3126 HVD Oil	Humble Oil and Refining Company
Brayco Micronic 756 C	Bray Oil Company
Royco 756 A	Royal Lubricants Company
PQ Hydraulic Fluid 4226	American Oil and Supply Company
XSL 7828	Shell Oil Company
PED 3337, PED 3565	Standard Oil Company of California
Petrofluid 5606B	Pennsylvania Refining Company
YT-283	Union Carbide Chemical Company

MILITARY SPECIFICATION: MIL-H-6083B

HYDRAULIC FLUID, PETROLEUM BASE PRESERVATIVE, TYPE I

PROPERTIES	SPEC. REQ.	ROYCO* 783 B	UNIVIS** PJ-44
FLASH POINT (min.)	93°C (200°F)	99°C (210°F)	107°C (225°F)
POUR POINT (max.)	-59°C (-75°F)	< -59°C (< -75°F)	< -59°C (< -75°F)
VISCOSITY, 10^{-6} m^2/sec (Cs.)			
at 54°C (130°F) (min.)	10	10.05	11.3
at -40°C (-40°F)	800	795	695
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g)	Report	-	-
PRECIPITATION NUMBER	0	0	-
COLOR	Clear, transparent w/red dye	Pass	Pass
CORROSION AND OXIDATION STABILITY, 168 hr. at 121°C (250° F) Weight Change, 10^{-10} kg/m^2 (mg/cm^2) Steel	± 0.2	Passes	-
Aluminum Alloy	± 0.2	Passes	-
Magnesium Alloy	± 0.2	Passes	-
Cadmium-Plated Steel	± 0.2	Passes	-
Copper	± 0.6	Passes	-
No Pitting, Etching, or Corrosion at 20X	Pass	-	-
Viscosity Change, at 54°C (130°F), %	-5 to +20	-	-
Neutralization Number Increase (max.)	0.30	-	-
COPPER STRIP CORROSION, 72 hr. at 100°C (212°F)	< 3	Pass	-
CORROSION PROTECTION, 100 hr. at 49°C (120°F) and 100% RH	Pass		
LOW TEMPERATURE STABILITY, 72 hr. at -54°C (-65°F), No Gelling, Crystallization, or Separation	Pass	Pass	
SHEAR STABILITY, Method 3471,			
Viscosity Change at 54°C (130°F), %	Less than ref. fluid	Pass	-
Neutralization Number Increase	0.30	Pass	-
EVAPORATION, 4 hr. at 66°C (150°F)	Oily, nontacky	Pass	-
ADDITIVES:			
Antiwear (tricresyl phosphate)	Yes	Yes	-
Oxidation Inhibitors	Yes	Yes	-
Corrosion Inhibitors	Yes	Yes	-
Viscosity - Temperature Coefficient Improvers	Yes	Yes	-
RUBBER SWELL, Type "L", % Volume Increase	19.0 to 26.5	Pass	-

* Royal Lubricants Company
** Humble Oil and Refining Company

NOTES: For a description of this hydraulic preservative oil and recommended usage, see Section II.

In addition to the hydraulic fluids listed, several other manufacturers produce hydraulic fluids which meet the requirements of this specification.

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HYDRAULIC FLUID, PETROLEUM BASE, HIGH TEMPERATURE, FLIGHT VEHICLE

PROPERTIES	SPEC. REQ.	ORONITE 6294*	HUMBLE 3160**
VISCOSITY, 10^{-6} m^2/sec (Cs.)			
at -54°C (-65°F)	Report	39,306	25,900
-40°C (-40°F), Max.	4,000	3,672	3,800
-18°C (0°F), Max.	385	335.6	375
38°C (100°F)	-	14.62	15.41
99°C (210°F), Min.	3.20	3.21	3.32
288°C (550°F)	Report	0.57	0.56
VISCOSITY INDEX, Min.	89	90	92
POUR POINT, Max.	(-65°F)	(-70°F)	(-70°F)
FLASH POINT, Min.	(360°F)	(370°F)	(390°F)
NEUTRALIZATION NUMBER			
10^{-3} kg. KOH/kg (mg. KOH/g)	0.20 Max.	< 0.01	-
TRACE SEDIMENT, Volume %, Max.	0.025	-	-
DIELECTRIC STRENGTH, 20°C (68°F), Min.	11.8×10^6 Volts/m (300 volts/mil)	-	-
SPECIFIC HEAT, Joule/kg °C at -93°C	2,031	2,269	-
(Btu/lb °F) at (200°F), Min.	0.484	0.542	-
THERMAL CONDUCTIVITY:			
Watt/m °C at 204°C	0.000756	0.000828	-
(Btu/(sq. ft.) hr. (°F)/ft.) at (400°F) Min.	0.063	0.069	-
THERMAL EXPANSION: Per °C at 204°C	0.00108	0.00067	-
Per °F at (400°F), Max.	(0.00060)	0.00038	-
BULK MODULUS:			
0 to 68.9 x 10^6 N/m^2 at 38°C	1.38×10^9 N/m^2	1.76×10^7 N/m^2	-
(isothermal secant, 0 to 10,000 psi) at (100°F), Min.	200,000 psi	255,000 psi	-
SPECIFIC GRAVITY: 16°C/16°C (60°F/60°F)		0.8499	0.846
THERMAL STABILITY, 371°C (700°F), 6 hr.			
a. Viscosity Change at 38°C (100°F), %	± 25	-15.25	-17
b. Neutralization Number Increase	0.40	0.02	0.0
c. Appearance of Fluid	-	Pass	Pass
d. Metal Weight Change, 10^{-10} kg/m^2 (mg/cm^2)			
1. Naval Bronze	0.1	+0.04	+0.04
2. M10 Tool Steel	0.1	+0.08	+0.06
3. 52100 Steel	0.1	+0.08	+0.04
SWELLING OF SYNTHETIC RUBBER, % 204°C (400°F), 72 hr. Viton	10	2.78	2.6

MILITARY SPECIFICATION: MIL-H-27601

HYDRAULIC FLUID, PETROLEUM BASE, HIGH TEMPERATURE, FLIGHT VEHICLE

PROPERTIES	SPEC. REQ.	ORONITE 6294*	HUMBLE 3160**
LUBRICITY, Shell Four-Ball Wear Test, 1 hr., 600 rpm 65°C (167°F) 52100 Steel Max. Scar Dia.			
9.81 N (1 kg.) Load, 10^{-3} m. (mm.)	0.21	0.161	0.16
9.81 N (10 kg.) Load, 10^{-3} m. (mm.)	0.30	0.210	0.22
372.4 N (40 kg.) Load, 10^{-3} m. (mm.)	0.65	0.630	0.50
SOLID PARTICLE CONTAMINATION, Time to Filter 100 10^{-6} m^3 (ml.), Sample Through 0.45 x 10^{-6} m. (micron)	10 (max.)	< 10	
FILTER PARTICLE SIZE, Max.	100 10^{-6} m. (micron)	None	

* California Chemical Company, Oronite Division
** Humble Oil and Refining Company

NOTES: For a description of, and recommended uses of this material, see Section II.

This specification also contains tests covering foaming characteristics, resistance to oxidation and corrosiveness and oxidation stability not shown on this sheet. These were not included because of their length and complexity.

MILITARY SPECIFICATION: MIL-H-46004 (Ord.)

HYDRAULIC FLUID, PETROLEUM BASE, MISSILE

PROPERTIES	SPEC. REQ.	ROYCO* 760	HYD. OIL** 3124	EF*** 100
COLOR (clear and transparent)	Req.	Passes	Passes	Passes
SPECIFIC GRAVITY (± 0.008 qual. sample)	Req.	0.854	0.8483	0.8463
MATERIAL: Base Oil,	Petroleum	Petroleum	Petroleum	Petroleum
Additives: Oxidation Inhib., % Weight	< 2	Passes	-	Passes
Tricresyl Phosphate, % Weight	0.4 to 0.6	Passes	-	Passes
Others	Note (1)	-	-	-
FLASH POINT, Min.	93°C (200°F)	104°C (220°F)	104°C (220°F)	96°C (205°F)
FIRE POINT	-	-	-	104°C (220°F)
POUR POINT, Max.	-59°C (-75°F)	-68°C (-90°F)	< -73°C (< -100°F)	< -65°C (< -85°F)
VISCOSITY, $10^{-6}\cdot m^2/sec$ (Cs.)				
at -54°C (-65°F) (max.)	300	288	252.1	270.3
at -40°C (-40°F) (max.)	75	72.4	68.2	70.34
at 38°C (100°F) (min.)	2.8	2.91	2.89	2.93
at 99°C (210°F) (min.)	-	1.17	-	-
VISCOSITY STABILITY (1.0 hr.)				
-40°C (-40°F), % Viscosity Change (max.)	1.0	0		-0.4
-54°C (-65°F), % Viscosity Change (max.)	1.0	0.84	-	-0.04
PRECIPITATION NUMBER	0	-	0	0
NEUTRALIZATION NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g) (max.)	0.20	0.08	0.01	0.03
WATER, CONTENT, % (max.)	0.015	0.008	0.009	0.0047
CORROSION AND OXIDATION (168 hr. at 121°C (250°F) Weight Loss, 10^{-10} kg/m^2 (mg/cm^2) (max.)				
Steel	0.20	0.00	0.00	+0.03
Aluminum	0.20	0.00	0.00	-0.01
Magnesium	0.20	0.00	0.00	+0.01
Cadmium	0.20	0.00	0.00	+0.02
Copper	0.60	-0.06	0.00	0.00
Pitting, Etching, Corrosion	None	None	-	None
Viscosity Change at 38°C (100°F), %	-5 to +20	2.65	3.07	2.9
Neutralization Number Increase (max.)	0.20	0.00	0.01	+0.05
Separation or Gumming	None	None	Passes	-
LOW TEMPERATURE STABILITY 72 hr. at -54°C (-65°F) (no gel, crystallizing or solidification)	Pass	-	Passes	Passes

MILITARY SPECIFICATION: MIL-H-46004 (Ord.)

HYDRAULIC FLUID, PETROLEUM BASE, MISSILE

PROPERTIES	SPEC. REQ.	ROYCO* 760	HYD. OIL** 3124	EF*** 100
RUBBER SWELL (synth. "L"), % Volume (168 hr. at 70°C (158°F)	19 to 26.5	25.5	22.65	24.0
COPPER CORROSION, 72 hr. at 100°C (212°F)	Pass	Passes	Passes	Passes
SOLID PARTICLES, No./100 10^{-6} m^3 (max.) Partizle Size 10^{-6} m. (micron)				
5 to 15	2,500	570	1,343	469
16 to 25	1,000	100	318	222
26 to 50	250	120	147	148
51 to 100	25	0	17	14
> 100	2	0	0	1.7
EVAPORATION, 4 hr. at 66°C (150°F)	Pass	Passes	Passes	Passes
CORROSIVITY, 10 Days, 27°C (80°F), 50% RH	No rust	Passes	Passes	Passes

* Royal Lubricants Company
** Humble Oil & Refining Company
*** California Chemical Corporation, Oronite Division

NOTES:

1. This low temperature hydraulic fluid shall contain no pour point depressants, viscosity index improvers, admixtures of resins, rubber, soap, gum, fatty oils, oxidized hydrocarbons, nor any other additives unless specifically approved. For a further description and recommended usage of this low temperature hydraulic fluid, see Section II.

2. In addition to the products listed, other hydraulic fluids which meet the requirements of this specification are:

Product Name	Manufacturer
Brayco 760	Bray Oil Company
Code 4646	Pennsylvania Refining Company

LOW VOLATILITY, SYNTHETIC HYDRAULIC FLUID

AIRCRAFT DISILOXANE BASE (Royal Lubricants Company)

PROPERTIES	ROYCO 820X
FLASH POINT	216°C (420°F)
FIRE POINT	243°C (470°F)
AUTO. IGNITION, Minimum	399°C (750°F)
USABLE TEMPERATURE RANGE	-54°C to 177°C (-65°F to 350°F)
VISCOSITY, 10^{-6} m^2/sec (Cs.)	
at 204°C (400°F)	3.7
at 99°C (210°F)	11.1
at 38°C (100°F)	32.0
at -54°C (-65°F)	2400
POUR POINT	-73°C (< -100°F)
LOW TEMP. STABILITY, 72 hr. at -54°C (-65°F)	Clear liquid, no haze or crystals
NEUTRALIZATION NO. 10^{-3} kg. KOH/kg (mg. KOH/g)	0.01
VAPOR PRESSURE, 204°C (400°F) N/m^2 (mm. Hg.)	133.32 (1.0)
RUBBER SWELL	
S Rubber, 70 hr. at 121°C (250°F), % Vol. Change	+7.0
26C Rubber, 148 hr. at 204°C (400°F), % Vol. Change	+10.0
HYDROLYTIC STABILITY, 48 hr. at 121°C (250°F)	
Weight Change, Copper, 10^{-10} kg/m^2 (mg/sq cm)	-0.02
Copper Appearance	Slight, dulling
Acid No. Change — Oil Layer	0.08
Acid No. Change — H_2O	0.02
Viscosity Change at 99°C (210°F), % Change	+1.8%
Insolubles, % Wt.	0.05
ADDITIVES	Oxidation, corrosion and hydrolysis

NOTES: Royco 820X is a disiloxane base synthetic hydraulic fluid with good viscosity temperature properties and low volatility. It also has good oxidation and corrosion properties and is shear stable.

USES: Newly designed aircraft and missile hydraulic systems operating at temperatures between -54°C and 177°C (-65°F and 350°F)and as a heat transfer media.

HIGH TEMPERATURE HYDRAULIC FLUID, SUPER REFINED,

PETROLEUM BASE (Bray Oil Company)

PROPERTIES	BRAYCO 777
FLASH POINT	210°C (410°F)
AUTO. IGNITION TEMPERATURE	388°C (730°F)
POUR POINT	-34°C (-30°F)
USABLE TEMPERATURE RANGE	-23°C to 371°C (-10°F to 700°F)
VISCOSITY, 10^{-6} m^2/sec (Cs); at 204°C (400°F)	1.6
99°C (210°F)	7.7
38°C (100°F)	72.8
-1°C (30°F)	1,513
-18°C (0°F)	11,547
VISCOSITY INDEX	69
DENSITY: kg/10^{-3} m^3 (g/ml) at 10^{-3} kg. KOH/kg, 16°C (60°F)	0.888
NEUTRALIZATION NO.: 10^{-3} kg. KOH/kg (mg. KOH/g)	0.0
CORROSION AND OXIDATION STABILITY: 5 x 10^{-3} m^3 (liters/hr), Air, 72 hr. at 175°C (347°F), Weight Change 10^{-10} kg/m^2 (mg/cm^2)	
Copper	+0.03
Aluminum Alloy	0.00
Magnesium Alloy	0.00
Steel	+0.02
Silver	-0.02
VISCOSITY CHANGE at 54°C (130°F), %	+1.8
NEUTRALIZATION NO. INCREASE, 10^{-3} kg. KOH/kg (mg. KOH/g)	+0.1

NOTE: Brayco 777 is a super refined, water white, petroleum base hydraulic fluid for high temperature operation and aerospace application. It is extremely resistant to shear breakdown and hydrolysis, and has excellent thermal and oxidation-corrosion stability. Usable temperature range of -23°C to 371°C (-10°F to 700°F) (closed system or inert atmosphere recommended over 204°C (400°F). Conventional oil and grease resistant paints and elastomers are compatible with Brayco 777. It conforms to hydraulic fluid MLO-7277 of Pennsylvania State University.

VERY LOW TEMPERATURE HYDRAULIC FLUID, MISSILE

PETROLEUM BASE (Bray Oil Company)

PROPERTIES	BRAYCO MICRONIC 762
GRAVITY, API, 16°C (60°F)	34.0 ± 0.5
SPECIFIC GRAVITY, 16°C (60°F)	0.855
COMPOSITION, Oil Base	Highly ref. petroleum
Additives	Oxidation, corrosion, antiwear
USABLE TEMPERATURE RANGE	-73°C to 204°C (-100°F to 400°F)
FLASH POINT, COC	99°C (210°F)
POUR POINT (no depressant allowed)	< -68°C (< -90°F)
CLOUD POINT	< -68°C (< -90°F)
APPEARANCE	Clear and transparent
COLOR, ASTM Code	2.5
VISCOSITY, 10^{-6} m^2/sec (Cs.)	
at -54°C (-65°F)	380
at -40°C (-40°F)	96.0
at 38°C (100°F)	3.4
at 54°C (130°F)	2.5
LOW TEMPERATURE STABILITY, 72 hr. at -54°C (-65°F)	Nongel, separation or cloud
CORROSION AND OXIDATION STABILITY, 168 hr. at 121°C (250°F)	
Weight Change, 10^{-10} kg/m^2 (mg/cm^2) Copper	0.30
Steel	0.00
Aluminum	0.02
Magnesium	0.01
Cadmium	0.01
Viscosity Change at 38°C (100°F), %	+5.30
Neutralization Number, 10^{-3} kg. KOH/kg (mg. KOH/g)	0.05
COPPER STRIP CORROSION, 72 hr. at 100°C (212°F) (slight brown perm. stain)	Passes
CORROSION PROTECTION, Steel, 100% RH at 38°C (100°F), Minimum	> 20.0
Static Water Drop, Minimum	> 100.0
SULFATED ASH, %	0.49
CALCIUM CONTENT, %	0.14
EVAPORATIVE RESIDUE, 4 hr. at 66°C (150°F) (not tacky)	Passes
SWELLING SYNTHETIC RUBBER, "L" Stock, 168 hr. at 70°C (158°F), %	+22
CLEANLINESS TEST, Avg. 10 Largest Part./250, 10^{-6} m^3 (ml.), Micron	40
Largest Single Particle, 10^{-6} m. (micron)	80

* Brayco-762; Bray Oil Company - Also marketed as Royco 762, Royal Lubricants Company (manufactured by Bray Oil Company)

Brayco Micronic 762 meets the requirements of Hughes Aircraft Specification HMS-20-1124B; Martin Material Specification MMS-N515-1; and proposed Military Specification MIL-H-25598 (USAF).

PROPERTIES		ROYCO 745* ROYCO MICRONIC
FLASH POINT, COC		179°C (355°F)
POUR POINT		-46°C (-50°F)
VISCOSITY, 10^{-6} m^2/sec (Cs.)		
at 18°C (0°F)		1185
at 99°C (210°F)		3.82
ACID NUMBER, 10^{-3} kg. KOH/kg (mg. KOH/g)		0.05 Basic
EVAPORATION, 4 hr. at 66°C (150°F)		Oily
WATER, %		0.001
CORROSION AND OXIDATION STABILITY, Air at 121°C (250°F), 168 hr.		
Weight Change: 10^{-10} kg/m^2 (mg/cm^2)	Copper	-0.03
	Aluminum Alloy	-0.02
	Magnesium Alloy	-0.02
	Steel	-0.02
	Cadmium on Steel	-0.02
Viscosity Change at 54°C (130°F),%		+1.29
Neutralization Number Increase, 10^{-3} kg. KOH/kg (mg. KOH/g)		0.15
SWELLING OF SYNTHETIC RUBBER "L", %		20.13
CORROSION PROTECTION, 100% RH, at 38°C (100°F), hours		
Polished Panels		> 100
Sandblasted Panels		> 100
SULFATED RESIDUE, %		0.24
PARTICULATE CONTAMINATION per 100 x 10^{-6} m^3 (ml.)		
5 to 15 10^{-6} m. (microns)		680
15 to 25 10^{-6} m. (microns)		180
25 to 50 10^{-6} m. (microns)		80
50 to 100 10^{-6} m. (microns)		6
100+ 10^{-6} m. (microns)		2

* Royal Lubricant Company (also Brayco 745, Bray Oil Company)

NOTE: Royco 745 - A petroleum base, low viscosity hydraulic oil for solid fuel missile systems. It has good antiwear properties, controlled rubber swell, and excellent oxidation stability. It provides corrosion stability and is shear stable. The micronic grade has a guaranteed extremely low particulate contaminants level.

USE: Royco 745 - Designed for use in thrust vector control systems of missiles and other hydraulic systems where reliability and storage stability are major requirements.

Silicate Esters (Oronite Div., California Chemical Co.)

PROPERTIES	ORONITE M2-V	ORONITE 70	ORONITE 8200
FLASH POINT, COC	216°C (420°F)	221°C (430°F)	202°C (395°F)
FIRE POINT, COC	260°C (500°F)	-	-
AUTO. IGNIT. TEMP.	404°C (760°F)	391°C (735°F)	404°C (760°F)
DENSITY, 16°C (60°F), kg/10^{-3} m^3 (g/cc)	0.9464	0.953	0.932
POUR POINT	< -79°C (<-110°F)	-	-
VISCOSITY, 10^{-6} m^2/sec (Cs.)			
at -54°C (-65°F)	2650	2593	2,235
at 38°C (100°F)	17.6	24.4	32.5
at 99°C (210°F)	5.45	7.6	11.3
at 177°C (350°F)	2.14	-	-
at 204°C (400°F)	-	2.35	3.82
at 232°C (450°F)	1.32	-	-
NEUTRALIZATION NO. 10^{-3} kg. KOH/kg (mg. KOH/g)	0.04	0.14	< 0.10
VAPOR PRESSURE, N/m^2 (mm. Hg.) at 204°C (400°F)	77.33 (0.58)	106.66 (0.80)	399.97 (3.0)
OXIDATION AND CORROSION STABILITY; 204°C (400°F) 72 hr. Wt. Change: 10^{-10} kg/m^2 (mg/cm^2)			
Silver	Nil	+0.01	0.00
Aluminum	Nil	0.00	0.00
Steel	+0.01	-0.01	+0.02
Copper	-0.55	-0.18	+0.03
SHEAR STABILITY; 2 hr. Sonic Osc. Test, % Original Viscosity at 99°C (210°F)	98.8	98	67
FOAMING PROPERTIES; D892			
(a) Room Temp., 10^{-6} m^3 (ml.) Foam (Time to Break, Minimum)	130 (4.75)	Nil	-
(b) 93°C (200°F), 10^{-6} m^3 (ml.) Foam (Time to Break, Minimun)	40 (1.33)	Nil	350 (< 10.0)
THERMAL STABILITY; % 99°C (210°F) Viscosity After 2 hr. at 316°C (600°F)	-	-13.0	-64.0
OPERATING RANGE	-54°C to 260°C (-65°F to +500°F)	-54°C to 332°C (-65°F to +630°F)	-54°C to 271°C (-65°F to +520°F)
LUBRICITY; 4-Ball Wear Test (2 hr., 1,200 rpm, 135°C (275°F) 52100 Steel)			
98.1N (10 kg.) Load, Scar Dia., 10^{-3} m.	0.78	0.72	0.71
372.4N (40 kg.) Load, Scar Dia., 10^{-3} m.	0.88	0.99	1.32
VISCOSITY IMPROVERS	None	None	Yes

NOTES: Oronite M2-V has an operating range of -54°C to 260°C (-65°F to +500°F) and is recommended for Type III and higher aircraft hydraulic systems. It is a stable nontoxic fluid requiring no special handling. Contains no VI improvers, thus has good viscosity stability. Also has good thermal and shear stability and extended service life.

Oronite 70 is similar to M2-V but has higher temperature operating limits of -54°C to 332°C (-65°F to +630°F). It equals or exceeds most of the properties of M2-V and in addition is a nonfoaming fluid.

Oronite 8200 has operating temperature limits of -54°C to 271°C (-65°F to 520°F). Contains a polymeric VI improver and thus does not have the shear and thermal stability of either M2-V or 70 fluids.

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TYPICAL PROPERTIES OF GENERAL ELECTRIC SILICONE FLUIDS

Silicone Fluid	Flash Point, °C	Pour Point, °C	Specific Gravity, 25°C	VISCOSITY 10^{-6} m^2/sec (Cs.) at 25°C	Viscosity Temperature Coefficient	Refractive Index, 25°C	Surface Tension, 25°C, Dynes/Cm	Thermal Expansion (vol/vol/°C) 25°C to 150°C	Thermal Conductivity Watt/m°C, 66°C	Maximum Volatility % Wt. Loss 24 Hr. at 150°C (760 mm. Hg.)	Specific Heat Joule/kg	Electrical Properties: Dielectric Strength (kv/mil)	Electrical Properties: 25°C, 10^2 - 10^6 Cycles: Dissipation Factor	Electrical Properties: 25°C, 10^2 - 10^6 Cycles: Dielectric Constant	Electrical Properties: Volume Resistivity (ohm-cm.)
SF-96 or	-1	-68	0.759	0.65	0.33	1.375	15.9	0.00134	0.00068	100(at 99.5°C)	-	25.0	0.0001	2.20	1 x 10^{16}
SF-97	135	-84	0.916	5.0	0.53	1.397	19.7	0.00105	0.00080	90	837	35.0	0.00001	2.60	1 x 10^{15}
	> 232	-65	0.953	20.0	0.58	1.401	20.8	0.00107	0.00098	10	837	35.0	0.0001	2.68	1 x 10^{14}
	> 316	-50	0.974	2,000.0	0.60	1.4035	21.1	0.000925	0.00109	0.5	837	35.0	0.0001	2.75	1 x 10^{14}
Viscail	> 316	-49	0.975	5,000.0	0.60	1.4035	21.3	0.000925	0.00108	2.0	837	35.0	0.0001	2.75	1 x 10^{14}
	> 316	-40	0.978	100,000.0	0.60	1.4035	21.3	0.000925	0.00108	2.0	837	35.0	0.0001	2.75	1 x 10^{14}
SF-81 or	> 232	-84	0.962	20	0.61	1.402	21.0	0.000976	0.00098	10.5	837	35.0	0.0001	2.71	1 x 10^{14}
SF-85*	> 316	-84	0.962	50	0.57	1.403	21.0	0.00095	0.00104	0.5	837	35.0	0.0001	2.74	1 x 10^{14}
SF-99	63	-	0.970	10	0.59	-	20.5	-	-	0.36	-	-	-	-	-
SF-1017	302	-46	1.07	125	0.76	1.495	24.7	0.00074	0.00098	0.30	906	32.5	0.0005	2.88	1 x 10^{14}
SF-1038	282	-73	0.99	50	0.62	1.425	25.0	0.00096	0.00102	1.0	906	32.5	0.0003	2.79	1 x 10^{14}
	304	-73	0.99	500	0.65	1.425	24.4	0.00096	0.00108	0.5	906	32.5	0.0003	2.80	1 x 10^{14}
SF-1053	241	-66	0.94	11	0.56	1.400	21.0	0.00108	0.00090	0.25	837	35.0	0.0001	2.68	1 x 10^{14}
SF-1055	316	-55	0.968	100	0.59	1.430	22.3	0.000925	0.00108	1.5	837	-	-	-	-
F-50	> 288	-73	1.05	70	0.68	1.4280	21.0	0.000975	0.00104	0.5	790	29.0	0.0013	2.90	8 x 10^{12}
F-44	> 288	-73	1.05	75	0.68	1.4290	21.0	0.00975	0.00104	0.5	790	-	-	-	-

* General Electric SF-85 electrical grade silicone fluids are SF-81 fluids specially processed and tested to meet electrical grade specifications.

NOTES: 1. These are typical values for General Electric silicone fluids, several additional viscosity ranges are available in most grades within the limits shown.

APPLICATION GUIDE - GENERAL ELECTRIC SILICONE FLUIDS

		Damping Fluids								Heat Transfer				Power Transmission			Other Mechanical Uses				Lubrication				Electrical**			
Product	Nominal Viscosity	Dashpots	Aircraft Instruments	Time Delay Relays	Gyros	Shock Absorbers	Meters	Torsional Vibration Dampers	Timing Devices	Heating Baths	Low Temperature Baths	Heat Exchangers	Thermostats	Fluid Clutches*	Controlled Speed Devices*	Hydraulic Fluids	Fluid Springs	Electrical Discharge Machining Coolants	Rust Preventive Oil	Transducers	Lubricate O-rings	Lubricate Rubber or Plastic Parts	Base Fluids for Grease	Sliding Metal on Metal Lubrication	Coolant for Transformer Capacitors & Amplifiers	Coolant for Tubes, Rectifiers, Electronic Modules	Extreme Temperature Range Coolant	Curable Treatment for Electrodes
SF-96	5																X	X		X								
	10																X			X								
	20				X							X	X												X	X		
	50		X		X		X			X		X	X			X				X					X	X		
	100	X	X	X	X		X			X		X	X				X			X		X	X					
	200	X	X	X	X		X															X						
	350	X	X	X	X		X	X														X	X					
	500	X	X	X	X		X	X						X	X							X			X	X		
	1,000	X	X	X	X	X		X						X	X		X					X	X		X	X		
	2,000	X	X	X	X	X		X						X	X		X				X	X						
Viscasil	5,000	X	X	X	X	X		X	X					X	X						X							
	10,000	X	X	X		X		X	X					X	X		X				X		X					
	30,000	X	X	X		X		X	X					X							X							
	60,000	X	X	X		X		X	X					X							X							
	100,000	X	X	X		X		X	X					X							X							
SF-18	350																					X						
SF-81	20		X				X				X														X	X		
	50		X	X			X				X		X										X		X	X		
SF-99	10																											X
SF-1017	125									X		X								X					X	X		
SF-1038	50		X				X			X	X	X				X				X			X					
	100		X	X			X					X											X					
	500		X	X			X																					
SF-1053	11												X												X	X	X	
SF-1055	100																		X									
F-5( )	70															X							X	X				
F-44	75															X								X				

* Special blending of fluids may be required for obtaining specific shear viscosity characteristics.
** The SF-97 and SF-85 electrical grade versions of the SF-96 and SF-81 series are recommended for these applications.

TYPICAL PROPERTIES OF DOW CORNING SILICONE FLUIDS

Dow Corning Fluids	Viscosity, 10^{-6} m^2/sec (Cs.) 25°C (77°F)	Flash Point	Pour Point (Freezing point)*	Specific Gravity 25°C	Coefficient of Expansion (cc/cc/°C)	Refractive Index 25°C	Surface Tension, 25°C, Dynes/Cm	Thermal Conductivity Watt/m°C at 25°C	Boiling Point	Specific Heat Joule/kg			Electric Strength (volts/ml)	Dielectric Constant		Volume Resistivity (ohm-cm.)
										40°C	100°C	200°C		10^2 Cycles	10^6 Cycles	
200	0.65 to 20.0	-1°C to 232°C	-84°C* to -60°C	0.761 to 0.955	0.00096 to 0.00134	1.375 to 1.400	15.9 to 20.6	0.10042 to 0.14226	99.5°C-230°C at 760 mm. Hg. and 70°C-200°C 0.5 mm. Hg.	1444	1464	1502	250 to 350	2.18 to 2.68	2.18 to 2.68	1×10^{16} to 1×10^{14}
									Volatility (48 hr. wt. loss at temp.)							
	50 to 60,000	279°C to 316°C	-55°C to -41°C	0.960 to 0.973	0.00104 to 0.00096	1.402 to 1.4035	20.6 to 21.5	0.15062 to 0.15899	2.5% at 200°C to 2.0% at 200°C	1402	1443	1477	350 to 375	2.71 to 2.76	2.71 to 2.76	1×10^{14} to 2×10^{5}
210	1,000 to 30,000	316°C to 316°C	-58°C to -44°C	0.972 to 0.973	0.00096 to 0.00096	1.4035 to 1.4035	21.2 to 21.5	0.15899 to 0.15899	2.0% at 200°C to 2.0% at 200°C	-	-	-	350 to 375	2.74 to 2.76	2.74 to 2.76	5×10^{14} to 2×10^{15}
330	50	291°C	-100°C*	0.968	0.00107	1.4023	20.5	0.14226	3.2% at 200°C	1464	1506	1573	375	2.73	2.73	5×10^{14}
510	50 to 1,000	274°C to 274°C	-73°C* to -73°C*	1.00 to 1.00	0.00096 to 0.00096	1.425 to 1.425	25.0 to 24.7	0.14644 to 0.15481	14% at 250°C to 3% at 250°C	1556 / 1556	1657 / 1657	1824 / 1824	350 to 350	2.77 to 2.81	2.77 to 2.81	1×10^{14} to 1×10^{14}
550	125	302°C	-51°C*	1.07	0.00075	1.50	24.5	0.14644	9% at 250°C	1498	1615	1812	350	2.89	2.89	1×10^{14}
555	20	121°C	-43°C*	1.06	0.00093	1.49	25.0	0.12552	8% at 150°C	-	-	-	350	2.71	2.71	2×10^{14}
560	75	288°C	-70°C*	1.04	0.00095	1.436	23.0	0.15062	14% at 250°C	1464	1565	1728	350	2.92	2.92	2×10^{14}
710	500	302°C	-22°C	1.11	0.00077	1.533	28.5	0.14644	13% at 250°C	1519	1900	2113	350	2.95	2.95	1×10^{14}
FS 1265	300 to 10,000	260°C to 316°C	-48°C* to -32°C*	1.25 to 1.30	0.00095 to 0.00095	1.381 to 1.383	25.7 to 28.7	-	10% at 200°C to 1.5% at 200°C	-	-	-	200 to 175	6.95 to 7.35	6.90 to 7.30	3×10^{10} to 1.5×10^{11}

* These are typical values for Dow Corning Silicon Fluids; several viscosity ranges are available in each grade within the limits shown.

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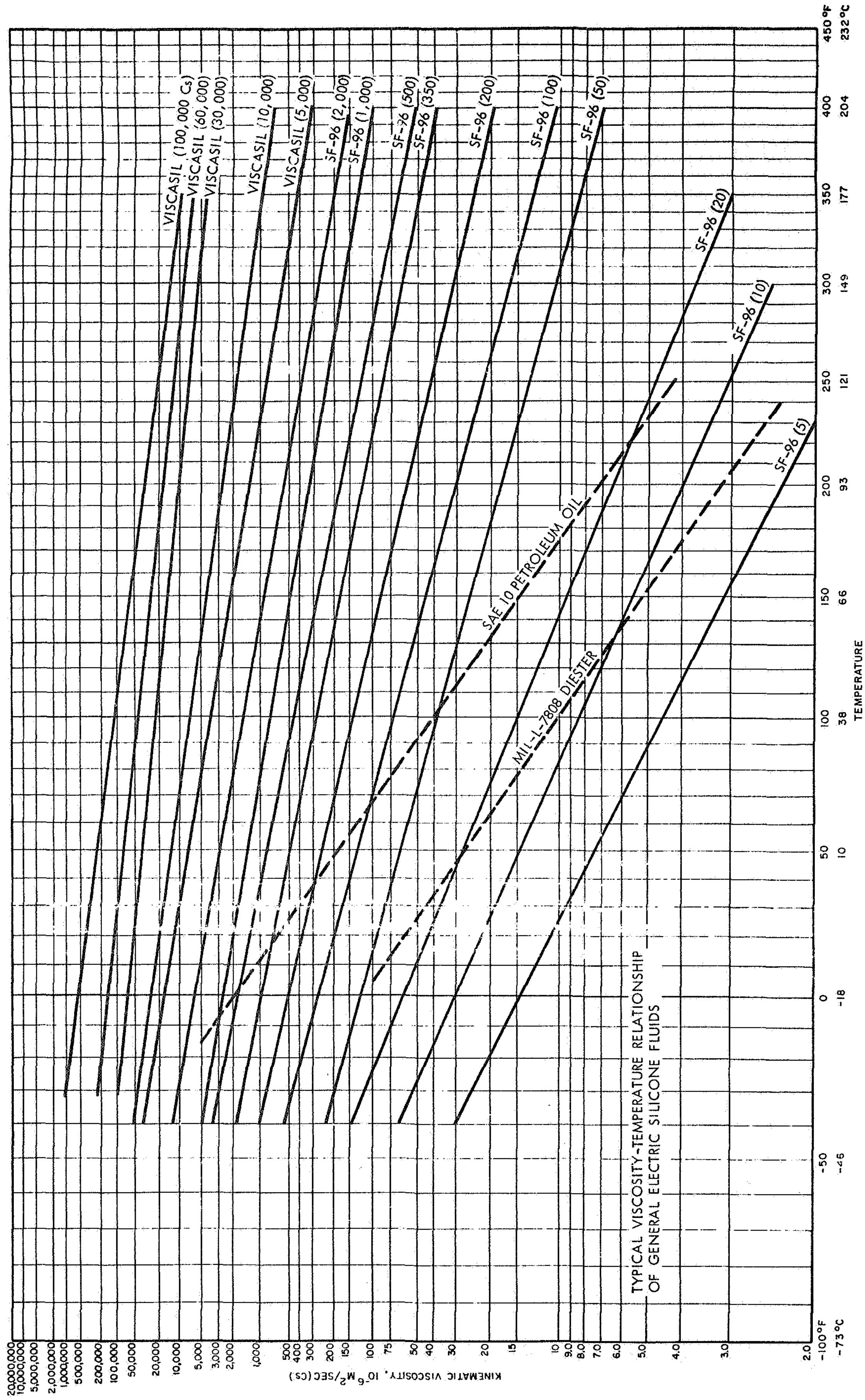
TYPICAL VISCOSITY-TEMPERATURE RELATIONSHIP OF GENERAL ELECTRIC SILICONE FLUIDS
VISCASIL (100,000 Cs)
VISCASIL (60,000)
VISCASIL (30,000)
VISCASIL (10,000)
VISCASIL (5,000)
SF-96 (2,000)
SF-96 (1,000)
SF-96 (500)
SF-96 (350)
SF-96 (200)
SF-96 (100)
SF-96 (50)
SF-96 (20)
SF-96 (10)
SF-96 (5)
SAE 10 PETROLEUM OIL
MIL-L-7808 DIESTER
TEMPERATURE
KINEMATIC VISCOSITY, 10^{-6} M^2/SEC (Cs)
-100°F -73°C
-50 -46
0 -18
50 10
100 38
150 66
200 93
250 121
300 149
350 177
400 204
450°F 232°C
20,000,000
10,000,000
5,000,000
2,000,000
1,000,000
500,000
200,000
100,000
50,000
20,000
10,000
5,000
3,000
2,000
1,000
500
400
300
200
150
100
75
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15
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9.0
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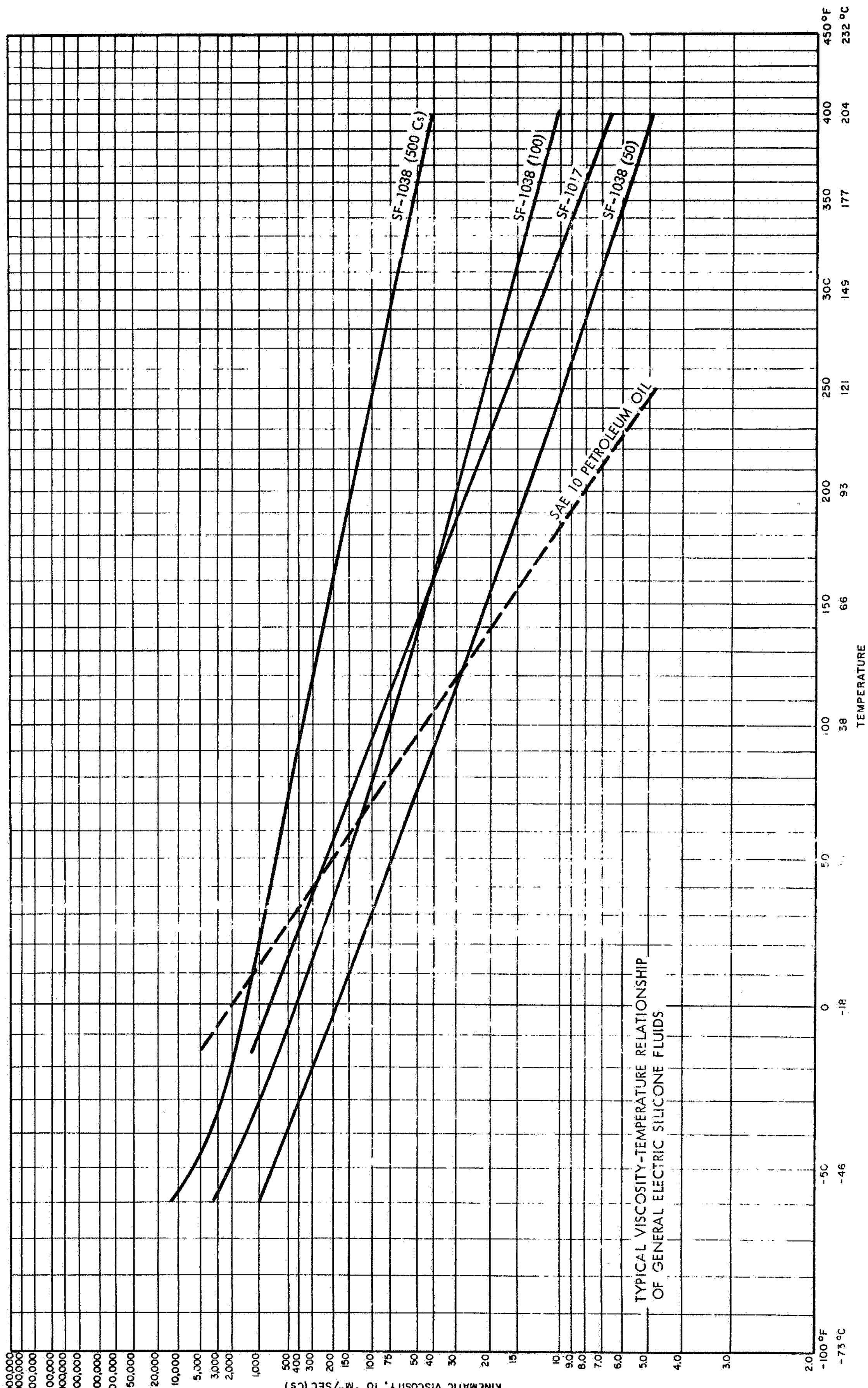
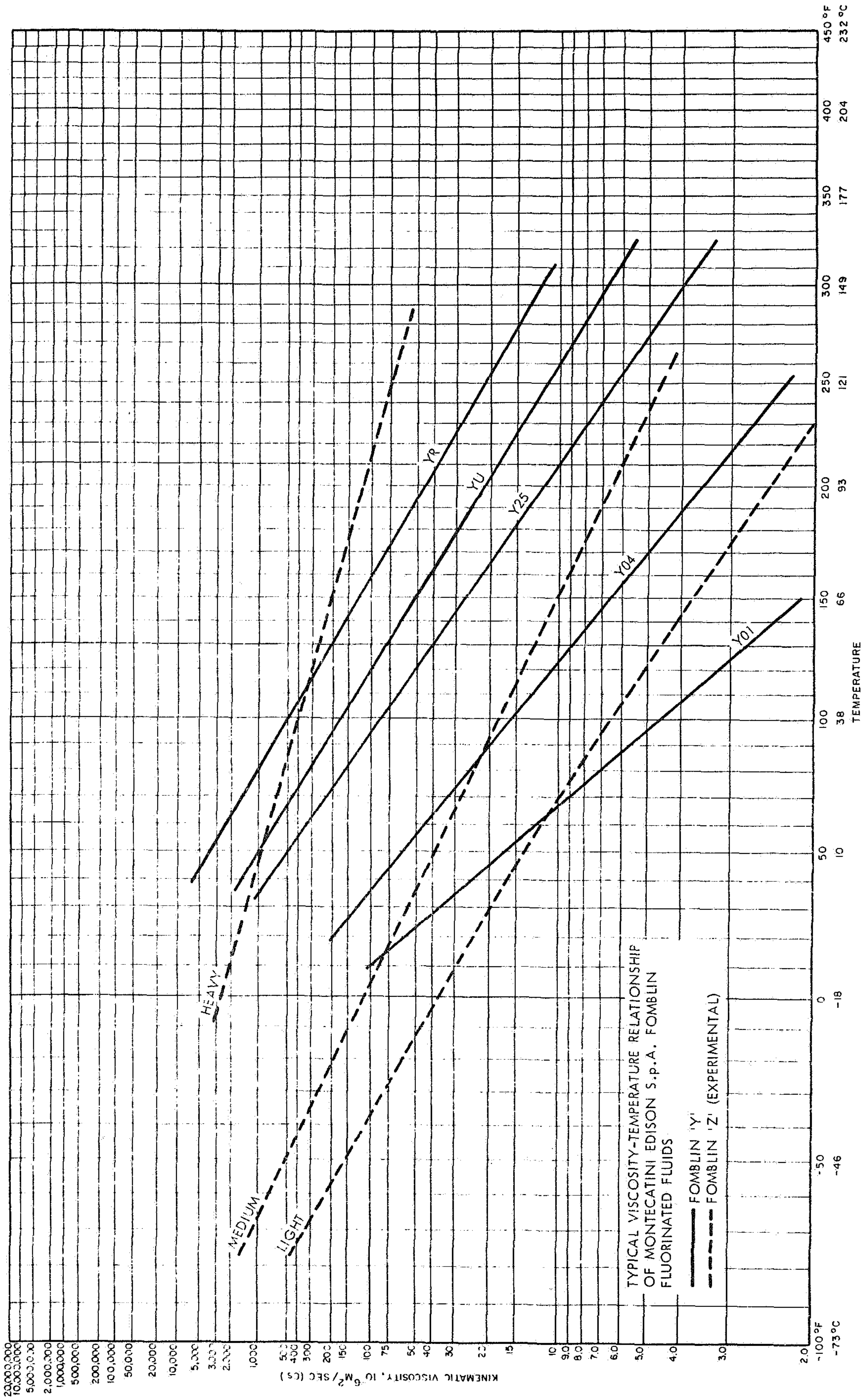
4.0
3.0
2.0


TYPICAL VISCOSITY-TEMPERATURE RELATIONSHIP
OF GENERAL ELECTRIC SILICONE FLUIDS
SF-1038 (500 Cs)
SF-1038 (100)
SF-1017
SF-1038 (50)
SAE 10 PETROLEUM OIL
TEMPERATURE
-100°F -73°C
-50 -46
0 -18
50
100 38
150 66
200 93
250 121
300 149
350 177
400 204
450°F 232°C
KINEMATIC VISCOSITY, 10-6M2/SEC (Cs)
20,000,000
10,000,000
5,000,000
2,000,000
1,000,000
500,000
200,000
100,000
50,000
20,000
10,000
5,000
3,000
2,000
1,000
500
400
300
200
150
100
75
50
40
30
20
15
10
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0



TYPICAL VISCOSITY-TEMPERATURE RELATIONSHIP
OF MONTECATINI EDISON S.p.A. FOMBLIN
FLUORINATED FLUIDS
FOMBLIN 'Y'
FOMBLIN 'Z' (EXPERIMENTAL)
YR
YU
Y25
Y04
Y01
HEAVY
MEDIUM
LIGHT
TEMPERATURE
-100 °F -73 °C
-50 -46
0 -18
50 10
100 38
150 66
200 93
250 121
300 149
350 177
400 204
450 °F 232 °C
KINEMATIC VISCOSITY, 10^{-6} M^2/SEC (CS)
20,000,000
10,000,000
5,000,000
2,000,000
1,000,000
500,000
200,000
100,000
50,000
20,000
10,000
5,000
3,000
2,000
1,000
500
400
300
200
150
100
75
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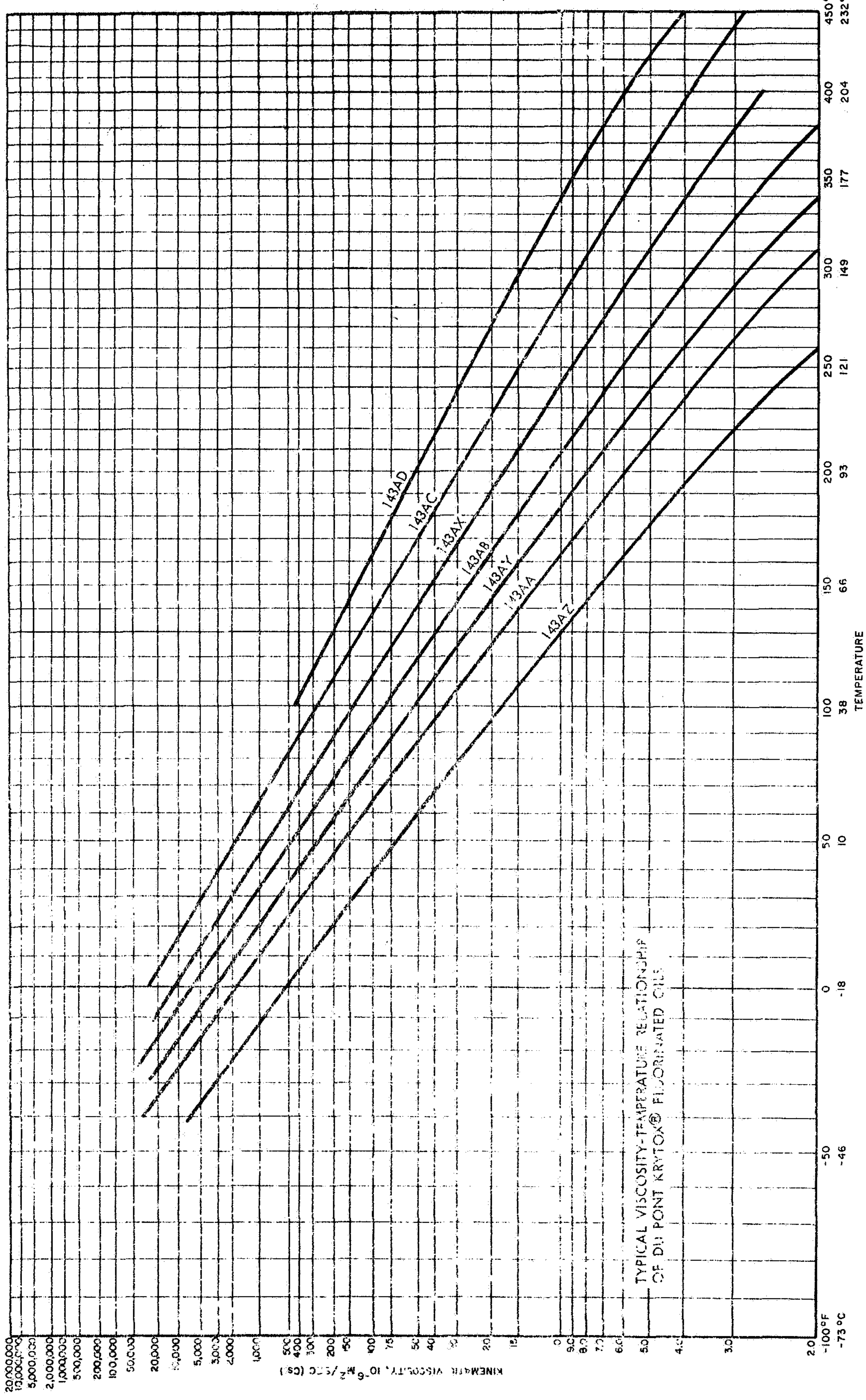
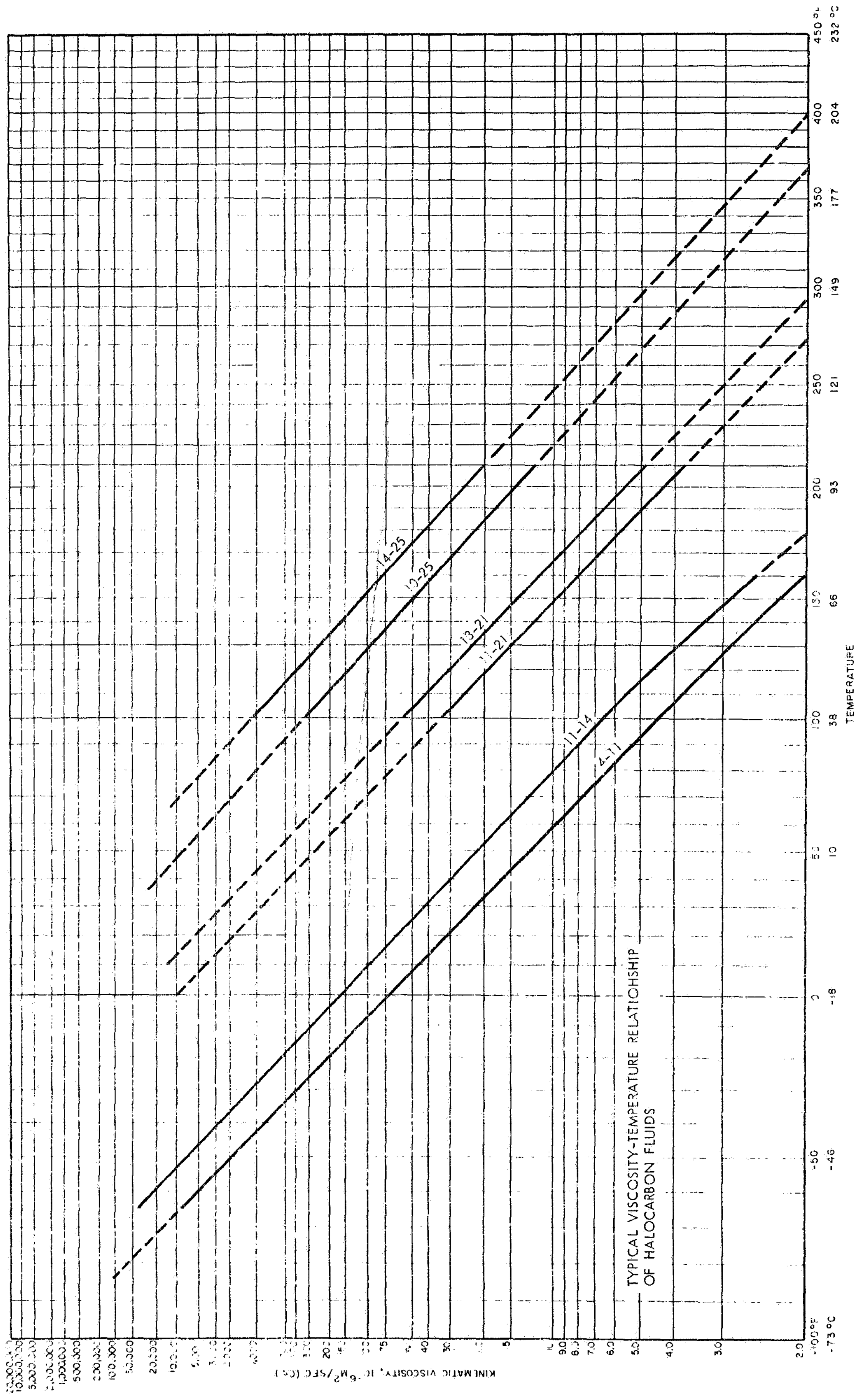
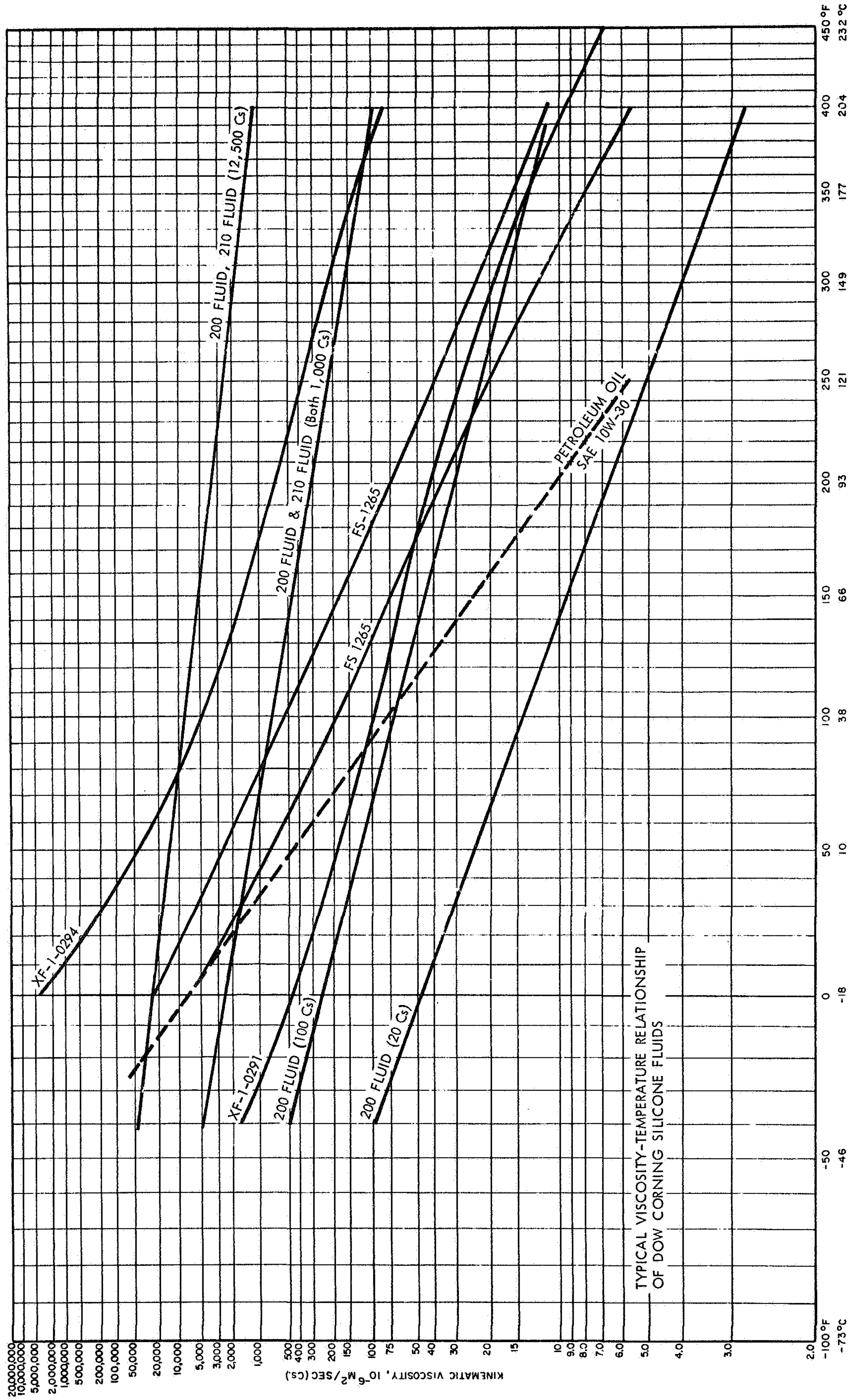
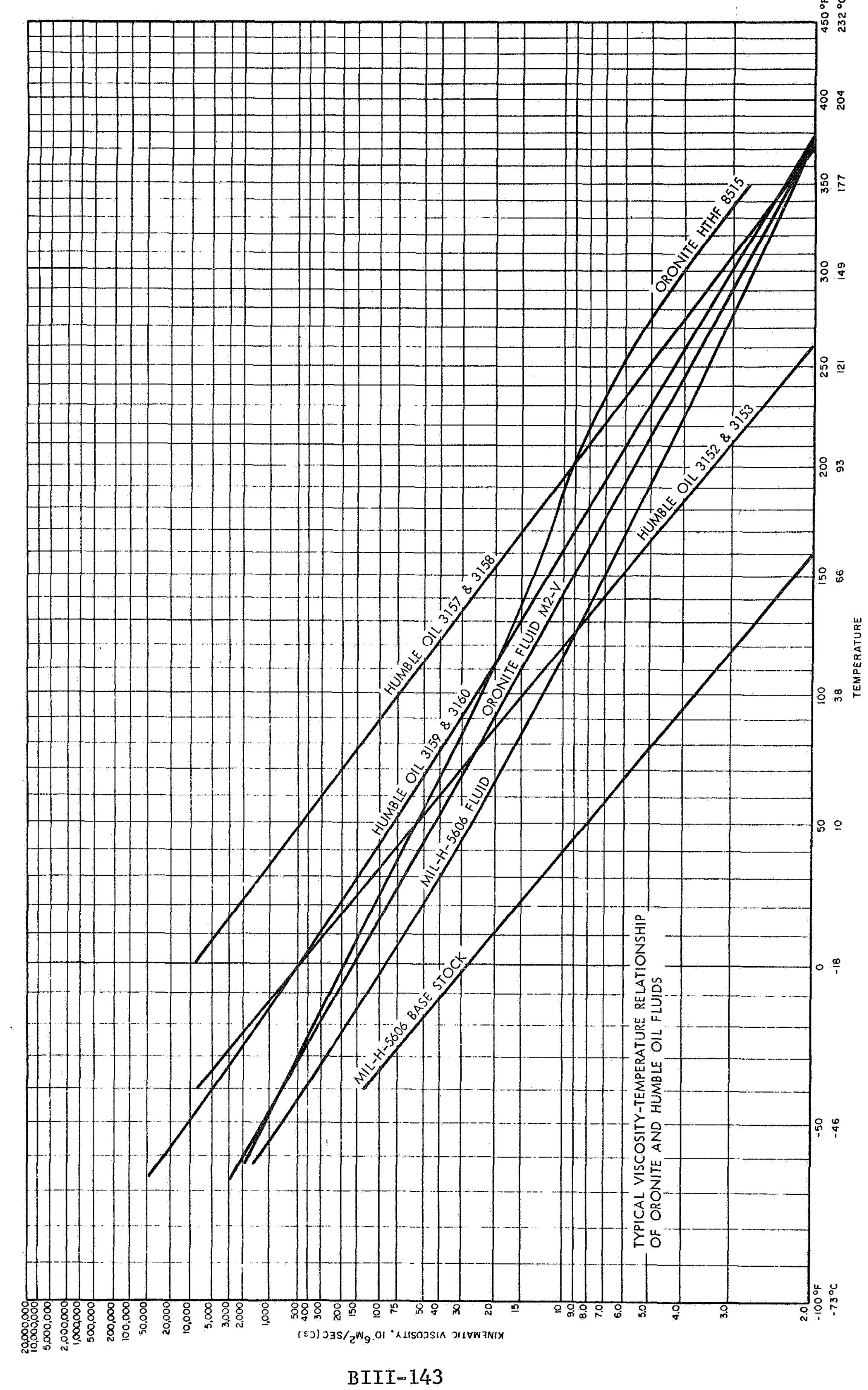
4.0
3.0
2.0


TYPICAL VISCOSITY-TEMPERATURE RELATIONSHIP
OF DU PONT KRYTOX® FLUORINATED OILS
143AD
143AC
143AX
143AB
143AY
143AA
143AZ
TEMPERATURE
-100°F -73°C
-50 -46
0 -18
50 10
100 38
150 66
200 93
250 121
300 149
350 177
400 204
450°F 232°C
KINEMATIC VISCOSITY, 10-6 M2/SEC (CS)
20,000,000
10,000,000
5,000,000
2,000,000
1,000,000
500,000
200,000
100,000
50,000
20,000
5,000
3,000
2,000
1,000
500
400
300
200
100
75
50
40
30
20
15
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0


TYPICAL VISCOSITY-TEMPERATURE RELATIONSHIP
OF HALOCARBON FLUIDS
14-25
10-25
13-21
11-21
11-14
4-11
TEMPERATURE
KINEMATIC VISCOSITY, 10^-6 M^2/SEC (cs)
-100°F -73°C
-50 -46
0 -18
100 38
150 66
200 93
250 121
300 149
350 177
400 204
450°F 232°C
20,000
40
30
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0


TYPICAL VISCOSITY-TEMPERATURE RELATIONSHIP
OF DOW CORNING SILICONE FLUIDS
200 FLUID, 210 FLUID (12,500 Cs)
200 FLUID & 210 FLUID (Both 1,000 Cs)
FS-1265
FS 1265
XF-1-0294
XF-1-0291
200 FLUID (100 Cs)
200 FLUID (20 Cs)
PETROLEUM OIL
SAE 10W-30
TEMPERATURE
KINEMATIC VISCOSITY, 10-6 M2/SEC (Cs)


TYPICAL VISCOSITY-TEMPERATURE RELATIONSHIP
OF ORONITE AND HUMBLE OIL FLUIDS
ORONITE HTHF 8515
HUMBLE OIL 3157 & 3158
HUMBLE OIL 3159 & 3160
ORONITE FLUID M2-V
HUMBLE OIL 3152 & 3153
MIL-H-5606 FLUID
MIL-H-5606 BASE STOCK
TEMPERATURE
KINEMATIC VISCOSITY, 10^{-6}M^2/SEC (CS)
-100 °F -73 °C
-50 -46
0 -18
50 10
100 38
150 66
200 93
250 121
300 149
350 177
400 204
450 °F 232 °C
20,000,000
10,000,000
5,000,000
2,000,000
1,000,000
500,000
200,000
100,000
50,000
20,000
10,000
5,000
3,000
2,000
1,000
500
400
300
200
150
100
75
50
40
30
20
15
10
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0

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BIV - APPENDICES A & B

APPENDIX A

LUBRICANT GLOSSARY

Additive: Any material added to a lubricating grease or a lubricating oil to improve its suitability for service. It may improve a property already possessed by the lubricant or give it properties not naturally possessed. Typical examples are antioxidants and "EP" or anti-weld additive.

Antioxidants: Any additive for the purpose of reducing the rate of oxidation and subsequent deterioration of oils or greases. (See oxidation stability.)

Apparent viscosity: The ratio of shear stress to rate of shear of a non-Newton fluid, as calculated from Poiseuille's equation and measured in poises. Apparent viscosity is dependent on temperature and rate of shear and therefore must be reported as the value at a given shear rate and temperature.

ASTM: An abbreviation for the American Society for Testing and Materials, which publishes a widely used set of standards for materials and test methods commonly known as the "ASTM Standards."

Bleeding: The separation of liquid lubricant from a lubricating grease for any cause. The showing of free oil on the surface of a grease or in the cracks of a cracked grease. Usually reported in percent weight loss.

Bomb Oxidation: The oxidation of a substance by combustion in a closed, sealed container, called a "bomb," containing oxygen under pressure. Results reported in pressure drop of the "bomb" psi, at a specified temperature, pressure and time.

Centistoke: 1/100th of a stoke. A stoke is the unit of kinematic viscosity with dimensions of square centimeters per second.

Cetane number: A measure of the ignition quality of a fuel or petroleum product with reference to normal cetane high ignition quality fuel with an arbitrary number of 100.

Cloud point: The temperature at which paraffin wax or other solid substances begin to crystalline out or separate from solution when an oil is chilled under definite prescribed conditions.

Compatibility: A measure of the ability of a lubricant to be mixed with other lubricants or petroleum products and form a uniform mixture without causing any resultant reaction or precipitation of material.

Contamination: The presence of foreign materials in a lubricant usually refers to solid material. Results are reported as the weight of foreign solid material per given weight of sample.

Corrosion: The gradual destruction and/or pitting of a metal surface due to chemical attack. This chemical attack may be, but is not necessarily, due to the formation of acidic materials in the lubricant.

Dielectric strength - kilovolts: Dielectric strength is a measure of the ability of a product to resist a flow of electric current through it and is measured as the minimum voltage in kilovolts that will produce arcing through the material under standard conditions.

Dirt content: A measure of the size and concentration of foreign particles present in a lubricant. Dirt content is usually reported as the number of particles per cubic centimeter, for specified particle sizes.

Distillation: A process for determining the range of temperature for which boiling occurs for a product and the temperature at which a certain percentage will be completely boiled off.

Dropping point: The temperature at which a lubricating grease passes from the semisolid to the liquid state under standard conditions of test. Dropping point is manifested by the falling of one drop of material from an orifice in the test apparatus. It is not the melting point of grease, but a temperature characteristic of the grease.

Emulsifiability: A measure of the ability of an oil to form and maintain an emulsion with water. Demulsibility, the exact opposite, is a measure of the ability of an oil to break from an emulsion.

Flash point: The lowest temperature of a lubricating oil at which vapors above the liquid surface will ignite, or flash, upon application of a small test flame. (Or) that temperature of a petroleum product where sufficient evaporation occurs so that the vapor to air ratio at the product surface is high enough to support momentary combustion (flash) when a source of ignition is present.

Flock point: A measure of the tendency of a lubricant to precipitate wax or other solids from solution. Depending on test used, the flock point is the temperature required for precipitation or the time required at a given temperature for precipitation.

Fluidity: The reciprocal of viscosity. In the cgs. system the unit of fluidity is the "rhe" which has the units of grams per centimeter second.

Fretting Corrosion: The oxidation of finely divided wear particles, which have been worn from bearing surfaces to a corrosion product. Corrosion, however, is not a part of the basic mechanism.

Gravity (API): Gravity is an expression of the weight-to-volume relationship of a product and is expressed as specific gravity, or weight per unit volume at a given temperature. API gravity is an arbitrary scale, in degrees, and is found from the specific gravity by:

$$\text{API gravity (degrees)} = \frac{141.5}{\text{specific gravity at } 60/60°\text{F.}} - 131.5$$

Insoluble matter: Components of a lubricant which are insoluble in the prescribed reagents used in an analytical procedure. The analytical procedure used should be indicated when insolubles are specified.

Kinematic viscosity: The quotient of the dynamic or absolute viscosity divided by the density, both determined at the same temperature. The cgs. unit of kinematic viscosity is the stoke (or centistokes where 1 stoke equals 100 cs.) which has dimensions of square centimeters per second.

Neutralization number: A measure of the acidity or alkalinity of an oil. Actually is not one number but several numbers (strong acid number, total acid number, strong base number, and total base number). The acid numbers are the number of milligrams of potassium hydroxide required to raise the pH of 1 g. of the sample to a certain value and the base numbers are the number of milligrams of hydrochloric acid required to lower the pH to a certain value. For uniform results, base numbers are converted to the number of milligrams of potassium hydroxide that the milligrams of hydrochloric acid required would neutralize to a pH value of 7. When only a neutralization is requested, it usually means the total acid number.

Oil separation: In greases, the separation of the oil present in the grease into free oil, usually evidenced as free surface oil. (See bleeding.) Reported in percent weight loss at specified conditions of temperature and time.

Oxidation stability: A measure of the resistance of lubricants to oxidation when stored under static conditions for long periods of time. (Or) a measure of the resistance of lubricants to oxidation, a chemical reaction between portions of the lubricant and any oxygen present.

Penetration: A arbitrary measure of the consistency (hardness) of lubricating grease. The depth, in tenths of a millimeter, that a standard cone penetrates the sample in a standard cup under prescribed conditions of weight, time, and temperature.

Unworked penetration: The penetration of a sample of lubricating grease which has received a minimum of handling and has not been subjected to the action of a grease worker.

Worked penetration: The penetration of a sample of lubricating grease after it has been brought to standard temperature and subjected to a prescribed amount of strokes in a standard grease worker.

pH value: An arbitrary scale for measuring the acidity or alkalinity of a product. Zero is maximum acidity, 14 is maximum alkalinity, and 7 is neutral.

Poise: The cgs. unit of dynamic or absolute viscosity which has the dimensions of grams per centimeter per second.

Saponification number: A measure of the amount of constituents of petroleum that will easily saponify under test conditions. The number of milligrams of potassium hydroxide which is consumed by 1 g. of oil under test conditions. Saponification number is a measure of fatty materials compounded in an oil.

Storage stability: A measure of the ability of a lubricant to undergo prolonged periods of storage without showing any adverse conditions due to oxidation, oil separation, contamination or any type of deterioration.

Viscosity: A measure of the flow characteristics of a fluid. The higher a fluid viscosity, the greater the resistance to flow. A viscosity usually varies with temperature; and is usually reported at a standard temperature.

Work factor: A measure of the stability of lubricants when subjected to an endurance test. The work factor is expressed as the average value of the ratio to three characteristics (viscosity, carbon residue, neutralization number) as measured before and after the test.

Fire point: The temperature at which the material will continue to burn for at least 5 sec. without the benefit of an outside flame.

Pour point: The pour point of a petroleum oil is the lowest temperature at which the oil will pour or flow when it is chilled without disturbance under definite prescribed conditions.

Autogenous ignition point: The temperature at which a liquid or semiliquid petroleum product ignites and burns without an outside flame or spark source. It is usually determined at atmospheric pressure in air of a controlled volume.

Saponify: To convert into soap; to subject to, or to undergo, saponification.

Absolute viscosity: The absolute or dynamic viscosity of a Newtonian liquid is the tangential force on unit area of either of two parallel planes at unit distance apart when the space is filled with the liquid and one plane moves relative to the other with unit velocity in its own plane. The cgs. unit of absolute viscosity is the poise, which has the dimension grams per cubic centimeters per second.

Channeling:

1. A term used in connection with lubricating greases to describe the usually desirable tendency to form a channel by working down of lubricating grease in a bearing, leaving shoulders of unworked grease which serve as seal and reservoir.

2. A term in connection with liquid lubricants and flow type lubricating grease to describe the tendency, at low temperatures, for these materials to form a plastic structure sufficiently strong to resist flow under gravitational forces only.

DN value: Product of bearing bore diameter in millimeters and speed in revolutions per minute.

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APPENDIX B

SUMMARIES OF STANDARD TEST METHODS

B.I. Test Methods for Lubricating Fluids

1. Autogenous Ignition Temperatures of Petroleum Products

Specification: ASTM D-286-58T

This method of test is intended for use in the determination of the autogenous ignition temperature of liquid and semiliquid petroleum products.

A flask is heated in a bath of molten alloy and small amounts of the sample are injected into the heated flask. The minimum temperature at which ignition of the sample will occur is recorded.

Precision: Results should be duplicable to within ± 2°C of the indicated temperature.

2. Color of Lubricating Oil and Petroleum

Specification: Federal Test Method Standard No. 791a, Method 102.6, ASTM D-1500-58T

This method describes a procedure for the visual determination of the color of a wide variety of petroleum products such as lubricating oils, heating oils, diesel fuel oils, and petroleum waxes.

A measured sample of test fluid is diluted with kerosene and placed in a standard glass sample jar in a colorimeter and its color is compared to the color of standard glasses. The color of the sample is reported as the color of the next darkest glass standard that matches it.

Precision: The following data should be used for judging the acceptability of results. Results should not be considered suspect unless they differ by more than the following amounts:

Repeatability - 0.5 color units
Reproducibility - 0.5 color units

3. Cloud and Pour Points

Specification: Federal Test Standard No. 791a, Method 201.8
ASTM D-97-57

This method describes procedures for determining the cloud point for oils which are transparent in layers 3.8×10^{-2} m. (1-1/2 in.) in thickness and for determining pour point for any petroleum oil. Cloud point is that temperature at which paraffin wax or other solid substances begin to crystallize out or separate from solution when the oil is chilled under prescribed conditions.

Cloud point: A sample of the oil is placed in a test jar and is chilled slowly. At intervals of 1°C (2°F), other samples are inspected for clouding. When a distinct cloudiness or haze appears at the bottom of the test jar, the temperature reading is recorded as the cloud point.

Pour point: A sample of the oil is placed in a test jar and heated to a predetermined temperature. The sample is then chilled slowly and at intervals of 2.8°C (5°F), the jar is tilted and the oil is inspected for movement. When the oil reaches a temperature where the jar can be tilted horizontally for 5 sec. with no movement, the pour point is taken as the temperature 2.8°C (5°F) above the solid point temperature.

Precision: Individual results of the pour point in one lab may vary by 2.8°C (5°F) and in different labs by 5.6°C (10°F), although the average of three or more results in different labs should show a difference between averages no greater than 2.8°C (5°F).

4. Pour Stability Characteristics

Specification: Federal Test Method Standard No. 791a, Method 203

This method is used for determining the pour stability of blends of winter grade (regular, heavy duty, and diluted heavy duty) motor oil, and of certain types of hydraulic fluids.

A sample of the oil is placed in a glass jar in a cooling bath and subjected to a predetermined schedule of temperature variations, and then determining the lowest temperature at which no surface movement will occur when the sample is turned horizontally for 3 sec.

Precision:

Repeatability: Results may vary by 2.8°C (5°F) for oils with poor pour stability characteristics. For blends with solid points below -18°C (0°F), the results may vary 5.6°C (10°F).

Reproducibility: Results may vary by 5.6°C (10°F). The average of three or more results in different laboratories show (should) not differ between averages no more than 2.8°C (5°F).

5. Pour Point

Specification: Federal Test Method Standard No. 791a, Method 204

This method is used for indicating the flow characteristic of engine oils that have been diluted with aviation gasoline.

A sample of the oil is diluted with a mixture of naphtha and xylene and then the pour point is determined as outlined in ASTM Method D-97 (Federal Test Method 201) cloud and pour point.

Precision: The same limits as set forth in ASTM D-97 (Federal Test Method 201) apply to this method.

6. Kinematic Viscosity

Specification: Federal Test Method Standard No. 791a, Method 305.4
ASTM D-445-61

This method describes the procedure for determining the kinematic viscosity of transparent or opaque fluids in the range of 0.2 cs. and higher. Determinations may be made at any temperature when the flow in the glass capillary-type viscometers is Newtonian.

The time is measured for a fixed volume of the liquid to flow through the capillary of a calibrated glass capillary-type viscometer under an accurately reproducible head and at a closely controlled temperature. The kinematic viscosity is then calculated from the efflux time and the viscometer calibration factor.

Precision: For clean transparent oils tested at 38.0°C (100°F) and 100°C (212°F), results should not be considered suspect unless they differ by more than the following amounts.

Repeatability - 0.35% of mean
Reproducibility - 0.7% of mean

7. Viscosity and Viscosity Stability at -54°C (-65°F)

Specification: Federal Test Method Standard No. 791a, Method 307

This method is used for determining the kinematic viscosity of transparent lubricants at -54°C (-65°F), and the stability with respect to time of this viscosity at -54°C (-65°F).

A sample of the lubricant is placed in a calibrated glass-type viscometer in a bath at -54°C (-65°F). The kinematic viscosity is then calculated. The viscometer and the sample are kept in the bath at -54°C (-65°F) for 72 hr. and calculation of the kinematic viscosity is made at different intervals during the 72 hr. to determine the viscosity stability at -54°C (-65°F).

8. API Gravity of Petroleum Products

Specification: Federal Test Method Standard No. 791a, Method 401.5
ASTM D-287-55

This method describes a procedure for the determination by means of a glass hydrometer of the API gravity of petroleum products normally handled as liquids and having a Reid Vapor pressure of 11.8 kg. (26 lb.) or less.

A sample of fluid is heated to the proper test temperature and placed in a glass cylinder. The hydrometer is inserted, and the API gravity in degrees is read from the hydrometer and the temperature of the sample is noted. All readings are then corrected to API gravity at 15.8°C (60°F).

Precision: The following criteria should be used for judging results obtained at temperatures of 15.8°C ± 10°C (60°F ± 18°F). Results should not be considered suspect unless they differ by more than the following amounts.

Repeatability - 0.2 degrees API
Reproducibility - 0.5 degrees API

9. Flash and Fire Point (Cleveland Open Cup)

Specification: Federal Test Method Standard No. 791a, Method 1103.6, ASTM D-92-57

This method describes a procedure for determining the flash and fire points of petroleum products except fuel oils and those having an open cup flash below 79°C (175°F).

The test cup is filled with the sample. The temperature of the sample is increased rapidly and then at a slow constant rate as the flash point is approached. At specified intervals, a test flame is passed over the cup. The lowest temperature at which application of the test flame causes the vapors above the surface of the sample to ignite is taken as the flash point. The test is continued until the application of the test flame causes the oil to ignite and burn for at least 5 sec. That temperature is the fire point.

Precision: The following data should be used for judging the acceptability of results. Results should not be considered suspect unless they differ by more than the following amount:

Repeatability	- flash point, 8.3°C (15°F)
	fire point, 5.5°C (10°F)
Reproducibility	- flash point, 16.7°C (30°F)
	fire point, 11.1°C (20°F)

10. Thermal Oxidation Stability of Gear Lubricants

Specification: Federal Test Method Standard No. 791a, Method 2504

This method is used for determining the deterioration of lubricants under severe oxidation conditions.

A sample of the oil is placed in a gear case in which two spur gears and a test bearing are operated under a load. The gear case is heated to 163°C (325°F ± 1°) and air is bubbled through the lubricant at the rate of 0.0011 m^3 (1.11 liters) per hour as 6,894 N/m^2 (1.0 psi). A copper strip is placed in the gear box with the lubricant.

The test apparatus is operated for 30 min. and then stopped and the viscosity of the lubricant is determined. The test apparatus is then operated continuously, and viscosity measurements taken every 10 hr. until the desired viscosity is obtained.

At completion of test, the apparatus is then examined and all deposits are recorded as well as the conditions of the gears, bearings, and the copper strip and any wear of the bearing is noted.

11. Thermal Stability of Lubricating and Hydraulic Fluids

Specification: Federal Test Method Standard No. 791a, Method 2508

This method describes a procedure for determining the thermal stability of fluid. In this method, the volatile decomposition products are held in continuous contact with the fluid during the test. This method does not measure the temperature of which oil fragments begin to form, but will indicate bulk fragmentation occurring at a specified temperature and testing period.

A sample is placed in a glass test cell, and all air and moisture are removed to reduce the variables of oxidation and hydrolysis. The cell is then sealed airtight under a vacuum and heated to 260°C ± 1°C (500°F ± 2°F) for a period of 24 hr. The sample is then observed for evidence of insolubles,phase separation, or other change. The specimen is removed from the cell and the kinematic viscosity (Federal Method 306, ASTM D-1092) and the acid and base numbers (Federal Method 5106, ASTM D-664) are determined for the heated sample and an unheated specimen and the valves compared.

12. Trace Sediment in Lubricating Oils

Specification: Federal Test Method Standard No. 791a, Method 3004.4

This method is used for determining trace amounts (less than 0.05 volume %) of sediment in lubricating oils.

A 50 ml. sample of the test oil, mixed with 50 ml. of naphtha, is centrifuged at a relative centrifugal force of 600-700 for 10 min. The mixture is decanted and the sediment is left in the tube. Another mixture of 50 ml. naphtha and 50 ml. of oil is mixed in the tube and centrifuged for 10 min. The final volume of sediment is noted and the results are reported as the volume of sediment per 100 ml. of sample.

13. Contamination

Specification: Federal Test Method Standard No. 791a, Method 3006

This method is used for determining the degree of contamination caused by foreign solid material in engine oil.

A 0.015 m^3 (4 gal.) sample of the oil is mixed with 0.015 m^3 (4 gal.) of naphtha and the mixture is filtered through a 200-mesh sieve. The remaining solid material is weighed and reported as the weight of solid material in the specimen.

14. Precipitation Number of Lubricating Oils

Specification: Federal Test Method Standard No. 791a, Method 3101.5, ASTM D-91-61

This method gives the procedures for determining the precipitation number of steam cylinder stock and block oils, and may be used for other lubricating oils. The precipitation number is the number of milliliters of precipitate found when a sample of the lubricating oil is treated and centrifuged under prescribed conditions.

A 10-ml. sample of the lubricating oil is mixed with 90 ml. of precipitation naphtha and centrifuged at a relative centrifugal force of 600-700 for 10-min. periods. The amount of precipitate formed in milliliters is read as the precipitation number.

Precision: Results should not be considered suspect unless they differ by more than the following amounts:

Precipitation No., 0.00 - 1.20;
Repeatability, 10% of mean;
Reproducibility, 30% of mean.

15. Insolubles in Used Lubricating Oils

Specification: Federal Test Method Standard No. 791a, Method 3121.3
ASTM D-893-60T

This method describes the procedures for the determination of pentane and benzene insolubles in used lubricating oils. One procedure covers the determination of insolubles without the use of coagulant in the pentane. The second procedure covers the determination of insolubles in oils containing detergents and employs a coagulant for both the pentane and benzene insolubles.

In the first procedure, a sample of the used oils is mixed with pentane and centrifuged. The precipitate is washed with pentane twice, dried and weighed to give the pentane insolubles. For benzene insolubles, a separate sample is mixed with pentane and centrifuged. The precipitate is washed twice with benzene, and with benzene-alcohol, and once with benzene, dried and weighed to give the benzene insolubles.

In the second procedure a sample of used oil is mixed with pentane coagulant solution and centrifuged. The precipitate is washed twice with pentane, dried and weighed to give the coagulated pentane insolubles. For coagulated benzene insolubles, a separate sample is mixed with pentane-coagulant solution and centrifuged, the precipitate is washed twice with pentane, once with benzene-alcohol solution, and once with benzene, dried, and weighed to give the coagulated benzene insolubles.

Precision: The following data should be used for judging the acceptability of results. Results should not be considered suspect unless they differ by more than the following amounts:

Insolubles,%	Repeatability	Reproducibility
0.0 - 1.0	0.07%	0.10%
over 1.0	10% of mean	15% of mean

16. Foaming Characteristics of Lubricating Oils

Specification: Federal Test Method Standard No. 791a, Methods 3211.3 and 3212.1, ASTM D-892-63

This method test is intended for the determination of the foaming characteristics of lubricating oils at specified temperatures. Means of empirically rating the foaming tendency and the stability of the foam are described.

The sample is maintained at a temperature of 24°C (75°F), is blown with air at a constant rate for 5 min. and then allowed to settle for 10 min. The volume of foam is measured at the end of both periods. The test is repeated on a second sample at 93°C (200°F), and then after collapsing the foam, at 24°C (75°F).

Precision: The following data should be used for judging the acceptability of results. Results should not be considered suspect unless they differ by more than the following amounts at the end of the 5-min. blowing period.

Repeatability - 10 ml.or 15% of average, whichever is greater
Reproducibility - 10 ml. or 38% of average, whichever is greater

17. Compatibility of Turbine Lubricating Oils

Specification: Federal Test Method Standard No. 791a, Method 3403

This method is used to determine the compatibility of aircraft turbine lubricants with specific referee lubricants.

The sample lubricant is mixed with the referee lubricant in three different ratios of 10%, 50%, and 90%, by volume. The mixtures are then heated at 105°C ± 2°C (221°F ± 5°F) for 168 hr. The mixtures are thoroughly agitated and centrifuged for 10-min. intervals until the volume of sediment becomes constant. The results are reported as the average volume of sediment per mixture.

18. Stability of Lubricating Oils (Work Factor)

Specification: Federal Test Method Standard No. 791a, Method 3451.2

This method is used for determining the stability of lubricating oils when subjected to an endurance test. The specimen to be tested is examined before the test for the following: (a) Carbon Residue (Federal Test Method 5002); (b) Neutralization Number (Federal Test Method 5105); (c) Precipitation Number (Federal Test Method 3101); (Astra Method D-91); (d) Viscosity (Federal Test Methods 304 or 305, ASTM Method D-88 or D-445).

The specimen is then tested in a journal bearing with a babbitt-metal bearing. The journal is operated at 3000-5100 rpm/2000 ± 100 rpm for certain samples, with an oil pressure of 10 psig (15 psig for certain samples) and a bearing load of 1,034,100 N/m^2 (150 psi) for a period of 100 ± 1/2 hr. After the test, the oil is again tested for the above properties and a work factor number for the sample is calculated from the changes observed.

19. Separation Characteristics of Universal Gear Lubricants

Specification: Federal Test Method Standard No. 791a, Method 3455

This method is used for determining the separation characteristics of universal gear lubricants during storage.

A 100-ml. sample of the lubricant is stored in a dark room at room temperature 29°C ± 8°C (85°F ± 15°F) for 30 days and centrifuged and examined for solid separation. If none occurs, then the sample is stored for 30 more days. The sample is then centrifuged and examined for solid and/or liquid separation. If a solid separates, it is weighed and results are reported as the percent by weight of the nonpetroleum solid material in the sample. If a liquid separates, it is measured and the results are reported as the percent, by volume, of nonpetroleum liquid in the sample.

20. Hydrolytic Stability

Specification: Federal Test Method Standard No. 791a, Method 3457

This method is used for determining the resistance of an oil to reaction in contact with water. The test consists of tumbling; under specified conditions of time, temperature and tumbling rate, a mixture of test oil and water in a bottle containing a copper strip, and then testing for changes in the oil, water, and copper.

21. Swelling of Synthetic Rubbers

Specification: Federal Test Method Standard No. 791a, Method 3603.4

This method is used for determining the swelling effects of petroleum products upon synthetic rubber.

The volumes of three standard test sheets of rubber are determined by water displacement. The sheets are then immersed in the sample for 168 hr. at 70°C (158°F), and the average change in the volume of the sheets is computed. The results are reported as percentage change in the volume.

Precision: Test results by one operator, at one laboratory, shall not vary from the average by more than the following: if average volume change is 0-5% units, then variation must not exceed 0.5% unit; if average volume change is above 5% units, then variation must not exceed 1% units.

22. Swelling of Synthetic Rubber (Aircraft Turbine Lubricants)

Specification: Federal Test Method Standard No. 791a, Method 3604

This method is used for determining the swelling effects of aircraft turbine lubricants on synthetic rubber.

Three sheets of a standard test rubber are immersed with lubricant which is heated to 70°C ± 1°C (158°F ± 2°F). After their volume has been determined by water displacement, the rubber sheets remain in the heated lubricant for 168 hr. The sheets are then removed, cleaned, and any change in volume is determined by water displacement. The results are reported as the average percent volume change of the three rubber sheets.

Precision: Results should not differ by more than the following:

Repeatability - 1%
Reproducibility - 2%

23. Carbon Residue (Conradson)

Specification: Federal Test Method Standard No. 791a, Method 5001.9, ASTM D-189-62

This method describes a procedure for the determination of the carbon residue left after evaporation and pyrolysis of an oil, and is intended to provide some indication of relative coke-forming properties. It is generally applicable to relatively nonvolatile petroleum products which partially decompose on distillation at atmospheric pressure. Petroleum products containing ash-forming constituents will have an erroneously high carbon residue, depending on the amount of ash formed.

The weight quantity of the sample is placed in a crucible and subjected to destructive distillation. The residue undergoes cracking and coking reactions during a fixed period of severe heating. At the end of the heating period, the crucible with the residue is cooled in a dessicator and weighed. The residue remaining is calculated as a percentage of the original sample and reported as the Conradson carbon residue.

24. Deposit-Forming Tendencies of Aircraft Turbine Lubricants

Specification: Federal Test Method Standard No. 791a, Method 5003

This test method describes a procedure for determining the deposit and sludge-forming tendencies of aircraft turbine lubricants.

A sample of the lubricant is circulated, in a special decomposition tester, under prescribed conditions, for a prescribed period of time through an aerated test chamber containing an aluminum tube held at a constant temperature of 310°C $\pm$ 1°C (590°F $\pm$ 5°F). From the chamber the oil passes through a cooler, a line filter, a circulating pump and back into the chamber. At the end of 12 hr., the test run is stopped. The weight of solid decomposition products on the heated tube is recorded as coke. The weight of the products found in the line filter is recorded as sludge. The deposit rating is calculated from: deposit rating = sludge + 10 (coke).

Precision: The results should not differ by more than the following amounts:

Repeatability - 0.75 deposit rating
Reproducibility - 0.75 deposit rating

25. Neutralization Number by Color Indicator Titration

Specification: Federal Test Method Standard No. 791a, Method 5105.3
ASTM D-974-58T, Institute of Petroleum: IP-139/64T

This method is intended for the determination of acidic or basic constituents in petroleum products and lubricants soluble or nearly soluble in mixtures of toluene and isopropyl alcohol. It is applicable for the determination of acids or bases whose disassociation constants in water are larger than 10^{-9}; extremely weak acids or bases whose disassociation constants are smaller than 10^{-9} do not interfere.

To determine the total acid or strong base number, the sample is dissolved in a mixture of toluene and isopropyl alcohol containing a small amount of water, and the resulting single-phase solution is titrated at room temperature with standard alcoholic base or alcoholic acid solution, respectively, to the end point indicated by the color change of the added p-naphtholbenzoin solution (orange in acid and green-brown in base). To determine the strong acid number, a separate portion of the sample is extracted with hot water and the aqueous extract is titrated with potassium hydroxide solution, using methyl orange as an indicator. Calculate and report acid or base number as the number of milligrams of potassium hydroxide to neutralize 1.0 g. of the sample.

26. Neutralization Number by Potentiometric Titration

Specification: Federal Test Method Standard No. 791a, Method 5106.4
ASTM D-664-58

This method describes procedures for the determination of acidic or basic constituents in petroleum products and lubricants. The method resolves these constituents into groups, having weak acid, strong acid, weak base, and strong base ionization properties, provided the disassociation constants of the more strongly acidic or basic compounds are at least 1,000 times that of the next weaker groups.

A sample is dissolved in a mixture of toluene and isopropyl alcohol containing a small amount of water and titrated potentiometrically with alcoholic potassium hydroxide and hydrochloric acid solution, using a glass indicating electrode and a calomel reference electrode. The meter readings are plotted against the respective volumes of titrating solutions and the end points are taken at the inflection point in the resulting curve.

27. Sulfur (Bomb Method)

Specification: Federal Test Method Standard No. 791a, Method 5202.11, ASTM D-129-62

This method describes the procedure for the determination of sulfur in petroleum products that cannot be burned completely in a wick lamp. The method is applicable to any petroleum product sufficiently low in volatility that it can be weighed accurately in an open sample boat and containing at least 0.1% sulfur.

The sample is oxidixed by complete combustion in a bomb containing oxygen under pressure. The sulfur, as a sulfate in the bomb washings, is determined gravimetrically as barium sulfate. The results are reported as sulfur percent by weight.

Precision: Duplicate results should not be considered suspect unless they differ by more than the following amounts:

Sulfur (% by weight)	Repeatability	Reproducibility
0.1-0.5	0.04	0.05
0.5-1.0	0.06	0.09
1.0-1.5	0.08	0.15
1.5-2.0	0.12	0.25
2.0-5.0	0.18	0.27

28. Corrosion Test at 232°C (450°F)

Specification: Federal Test Method Standard No. 791a, Method 5305

This method is used for determining the corrosive tendencies of lubricants at high temperatures.

A prepared silver strip and a prepared copper strip are immersed in two samples of the lubricant and heated to 232°C (450°F) for 50 hr. The strips are then removed, washed, and weighed and any change of weight is recorded. The results are then reported as the average change in weight per square inch of the two strips.

Precision: Results should not differ by more than the following amounts:

Average Change (mg/sq. in.)	Repeatability	Reproducibility
0-3	0.3 mg/sq. in.	0.6 mg/sq. in.
above 3	10%	20%

29. Corrosiveness and Oxidation Stability of Light Oils (Metal Strip)

Specification: Federal Test Method Standard No. 791a, Method 5308.5

This method is used for testing hydraulic oils (and similar, highly refined, light oils) to determine their ability to resist oxidation and their tendency to corrode various metals.

Five different metal strips (one each of copper, steel, aluminum alloy, magnesium alloy, and cadmium-plated steel) are immersed in a sample of the oil and heated at 121°C (250°F) for 168 hr. while air is bubbled through. The strips are then removed and weighed and the results recorded as change in weight per square inch. Each strip is examined for any evidence of pitting or etching or stains. The oil sample is examined before and after the test for neutralization number (Federal Test Method 5105 or 5106) and for viscosity (Federal Test Method 305, ASTM D-445) and the percent of change of each is determined.

30. Copper Corrosion by Petroleum Products (Copper Strip Test)

Specification: Federal Test Method Standard No. 791a, Methods 5316 and 5325.2, ASTM D-130-56

This method describes procedures for the detection of the corrosiveness to copper of fuels, gasolines, cleaners, fuel oils, and other petroleum products.

A polished copper strip is immersed in a given quantity of the sample and heated at a temperature and for a time characteristic of the material being tested. At the end of the period, the copper strip is removed and compared with the ASTM copper strip corrosion standards. The results are reported as the class of corrosion the strip falls into.

31. Lead Corrosion Test

Specification: Federal Test Method Standard No. 791a, Method 5321.1

This method is used for measuring the corrosiveness of lubricating oils on lead in the presence of a copper catalyst.

A panel of lead and a panel of copper are attached to a stirrer after polishing and weighing. The stirrer is immersed in a sample of the lubricating oil which is heated to 163°C ± 1°C (325°F ± 2°F). The plates are rotated at 650 rpm for 60 hr. while air is bubbled through the oil. The lead panel is then weighed and any change in weight is recorded in milligrams per square inch of surface area.

Precision:

Weight Change (mg/sq. in.)	Repeatability	Reproducibility
0-10	1 mg/sq. in.	2 mg/sq. in.
above 10	10% of average	20% of average

32 Moisture Corrosion Characteristics of Gear Lubricants

Specification: Federal Test Method Standard No. 791a, Method 5326

This method is used to determine the corrosion preventive properties of gear lubricants. It duplicates normal service conditions wherein moisture condenses on the metal parts during cyclic ambient temperatures. The procedure can be used on new or used oil samples.

The sample and a small amount of water are placed in a differential assembly test unit with a prepared cover plate. The unit is maintained at 82°C (180°F) and operated at 2500 rpm for 4 hr. The unit is then stopped and placed in a storage box at 52°C ± 1°C (125°F ± 2°F) for a stipulated time (either 1 day or 7 days). The unit is disassembled and examined for evidence of corrosion.

33. Saponification Number (Color Indicator Titration)

Specification: Federal Test Method Standard No. 791a, Method 5401.8, ASTM D-94-62

This method of test intended for determining the amount of constituents in petroleum products that will easily saponify under the conditions of the test. The saponification number of an oil is the number of milligrams of potassium hydroxide which is consumed by 1 g. of oil under the conditions of the test.

A weighed sample of the oil, dissolved in methylethylketone, with a measured quantity of a standard alcoholic solution of KOH, is heated. The amount of unconsumed KOH is determined after heating by titration with a standard solution of HCl. The KOH consumed is calculated and divided by the weight of the sample.

Precision: With care, determination by different operators should agree within ± 0.5 saponification numbers for values less than 5.0, and within ± 0.7 saponification numbers for values above 5.0.

34. Ash Content

Specification: Federal Test Method Standard No. 791a, 5421.4 ASTM D-482-63

This method describes a procedure for determining the ash from distillate and residual oils, crude oils, lubricating oils, waxes, and other petroleum products, in which any ash-forming materials present are normally considered to be undesirable impurities or contaminants. The method is limited to products which are free from added ash-forming additives.

A measured sample of the product is placed in a suitable dish and ignited and allowed to burn until only ash and carbon remain. The carbonaceous residue is reduced to ash by heating in a muffle furnace at 775°C (1427°F), cooled in a dessicator, and weighed.

Precision: The following data should be used for judging the acceptability of results. Results should not be considered suspect unless they differ by the following amounts:

Ash (%)	Repeatability	Reproducibility
0.0-0.15	0.003	0.005

35. Sulfated Residue (New Lubricating Oils)

Specification: Federal Test Method Standard No. 791a, Method 5422.3, ASTM D-874-63

This method describes a procedure for determining the sulfated ash from unused lubricating oils containing additives and from additive concentrates used in compounding. These additives usually contain one or more of the following metals: barium, calcium, magnesium, zinc, potassium, sodium, and tin. They may be in combination with one or more of the elements sulfur, phosphorus, and chlorine. The sulfated ash may be used to indicate the concentration of additives in new oils.

A sample is ignited and burned until only ash and carbon remain. After cooling, the charred ash is treated with sulfuric acid and heated at 550°C (1022°F) until the oxidation of the carbon is nearly complete. The ash is then cooled, retreated with sulfuric acid, heated at 775°C (1427°F) and weighed.

Precision: The following data should be used for judging the acceptability of results. Results should be considered suspect unless they differ by more than the following amounts:

Sulfated Ash (%)	Repeatability	Reproducibility
0-1	0.04	4% of the mean
over 1	0.06	6% of the mean

36. Metals in Lubricating Oils

Specification: Federal Test Method Standard No. 791a, Method 5601.1, ASTM D-811-48

This method describes the procedures intended for the determination of barium, tin, silica, zinc, aluminum, calcium, magnesium, sodium, and potassium in new and used lubricating oils. Other metallic elements--sulfur, phosphorus, and chlorine in amounts commonly found in lubricating oils--do not interfere in this method.

The analytical procedures follow the well known scheme of separating the metals into groups for more convenient determination. This scheme provides a rapid and accurate method for the determination of all, several, or any one of the metals as may be seen necessary from an initial qualitative inspection of the oil sample.

37. Chlorine in Lubricating Oils (Bomb Method)

Specification: Federal Test Method Standard No. 791a, Method 5651.4, ASTM D-808-63

This method covers the determination of chlorine in lubricating oils and greases, including new and used lubricating oils and greases containing additives, and in additive concentrates. Its range of applicability is 0.1-50% chlorine.

A small sample is oxidized by combustion in a bomb containing oxygen under pressure. The chlorine compounds thus liberated are absorbed in a sodium carbonate solution and the amount of chlorine present is determined gravimetrically by precipitation as silver chloride.

Precision: The following criteria should be used for judging the acceptability of results. Results should not be considered suspect unless they differ by more than the following amounts:

Range of Chlorine Content (%)	Repeatability	Reproducibility
oil - 2 exclusive	0.07	0.10
2-5 inclusive	0.15	0.30
above 5	3% of amount present	5% of amount present

38. Phosphorus in Lubricating Oils

Specification: Federal Test Method Standard No. 791a, Method 5661.4, ASTM D-1091-58T

These methods are applicable to the determination of phosphorus in unused lubricating oils, lubricating oil additives, and their concentrates. The methods are not restricted with respect to the type of phosphorus compounds that may be present since all are quantitatively converted to an aqueous solution of orthophosphate ion by oxidation of the sample during the course of analysis.

The organic material in the sample is removed and the phosphorus is converted to phosphate ion by oxidation with sulfuric acid, nitric acid, and hydrogen peroxide. One of two procedures is then followed: the photometric method or the gravimetric method. The photometric method is used where the phosphorus content is estimated to be under 2%, and the gravimetric method for phosphorus contents of 2% or over.

39. Load Carrying Capacity (Mean Hertz Load)

Specification: Federal Test Method Standard No. 791a, Method 6503.1

This method describes a procedure for determining the load carrying ability of a lubricant under extremely high pressure.

A sample of the lubricant (500 ml.), either grease or oil, is placed in the ball pot of a Shell Four Ball Extreme Pressure Tester. Three 1/2 in. steel bearing balls are held stationary in the ball pot and immersed in the lubricant. A fourth ball is mounted in a rotating chuck to which a thrust load is applied and rotated at 1800 rpm against the three stationary balls. The bearing thrust load of 40 kg. is increased in 5 kg. increments until welding occurs. Welding is indicated by a sharp traverse movement of the indicator pen signifying momentary locking of the four balls. The mean loads are calculated from the sizes of the scars produced.

40. Load Carrying, Wear, and Extreme Pressure Characteristics of Gear Lubricants in Axles Under High Speed, Low-Torque Operation, Followed by Low-Speed, High-Torque Operation

Specification: Federal Test Method Standard No. 791a, Method 6506

This method is used for determining the load carrying, wear and extreme pressure characteristics of gear lubricant in axles under conditions of high-speed, low-torque, and low-speed, high-torque operation, using a single set of gears.

A sample of the oil is placed in a test assembly of a hypoid rear axle carrier. The assembly is then driven at 445 rpm with a torque of 1,069 N m. (9,460 lb-in) and, with the lubricant at 149°C (300°F) for 100 min., for the high-speed, low-torque test. The apparatus is then examined (still intact) for corrosion. The assembly is then driven at 80 rpm with a torque of 4,723 N m. (41,800 lb-in) and with the lubricant at 135°C (275°F) for 24 hr. The apparatus is then disassembled and examined for wear, corrosion, deposits, discoloration, rust, fatigue, scratches, burnishing, etc.

41. Load Carrying and Extreme Pressure Characteristics of Gear Lubricants in Axles Under Conditions of High Speed and Shock Loading

Specification: Federal Test Method Standard No. 791a, Method 6507

This method is used for determining the antiscoring properties of gear lubricants under high speed and shock conditions.

A sample of the lubricant is placed in a test assembly of a Spicer Model 44-1 rear axle, 47 to 12 ratio. An examination of the gear teeth is made before testing. The apparatus is then operated beginning at 99°C (200°F). Lubricant temperature while the axle speed is accelerated from 550-1,100 rpm and then decelerated to 550 rpm for 5 cycles with inertia torque only. Without disassembling, the nature, extent and location of the drive and coast contact areas are observed and recorded. Then, beginning at 138°C (280°F) lubricant temperature, the apparatus is operated with a 178 N m. (131 ft/lb) torque on each axle while the speed is accelerated rapidly from 550-650 rpm and decelerated rapidly to 550 rpm for 10 cycles. The apparatus is disassembled and the nature, extent and location of drive and coast contact areas are noted and any disturbances to the ring gear tooth forces.

42. Load Carrying Ability of Lubricating Oils (Ryder Gear Machine)

Specification: Federal Test Method Standard No. 791a, Method 6508

This method describes a procedure for determining the load carrying ability of lubricating oils with respect to gears.

Two special test gears are mounted in a Ryder Gear-Erdco Universal Tester. The test oil is heated to 74°C (165°F) and the gears rotated at 10,000 rpm in cycles of 10 min. each with uniform increases in gear load for each cycle. The gears are examined for scuffing at the end of each cycle. The cycles are continued until a preset percent of gear tooth scuffing is observed. The load carrying ability is that gear tooth load which produces an average gear tooth scuffing of 22.5% of force areas. Results are reported as the percent of load carrying ability of the test oil to a reference oil.

Precision:

Repeatability: Relative readings should not differ from their mean by more than 10%.

Reproducibility: Relative readings should not differ from their mean by more than 5%.

43. <u>Gear Fatigue Characteristics of Aircraft Gas Turbine Lubricants at 204°C (400°F)</u>

Specification: Federal Test Method Standard No. 791a, Method 6509

This method describes a procedure for determining the fatigue characteristics of aircraft gas turbine engine lubricants at 204°C (400°F) with respect to gears.

Two special test gears are mounted in a WADD High-Temperature Gear Machine adapted to a modified Ryder Gear-Erdco Universal drive system. The test oil is heated to 204°C (400°F) and the gears rotated at 10,000 rpm in 10 min. cycles with uniform increases in load at each cycle. At the end of each cycle the gears are examined for scuffing. When a predetermined maximum load is reached, the cycle duration is increased to 2 hr. at constant load. At the end of each cycle, the gears are then observed for development of fatigue pits which are large enough to be readily discernible to the eye.

Results are reported as the percent of load carrying ability with respect to a reference oil of the test oil and the rating of each fatigue cycle in terms of the number of fatigue pits.

44. <u>Load Carrying Ability of Lubricating Oils at 204°C (400°F)</u>

Specification: Federal Test Method Standard No. 791a, Method 6511

This method describes a procedure for determining the load carrying ability of lubricating oils at 204°C (400°F) with respect to gears.

Two special test gears are mounted in a WADD High-Temperature Gear Machine adapted to a modified Ryder Gear-Erdco Universal drive system. The test oil is heated to 240°C (400°F) and the gears rotated at 10,000 rpm in cycles of 10 min. with uniform increases in gear load for each cycle. The cycles are continued until a set percentage of gear tooth force scuffing is observed. The load carrying ability is that gear tooth load which produces an average gear tooth scuffing of 22.5%. Results are reported as the percent of load carrying capacity of the test oil to a reference oil.

45. <u>Viscosity Index (Calculation)</u>

Specification: Federal Test Method Standard No. 791a, Method 9111.2
ASTM D-567-53

This method gives the necessary equations and tables for the calculation of the viscosity index of a petroleum product or lubricant from its viscosity at 38°C (100°F) and 99°C (210°F). This method provides tables for oils with viscosities at 99°C (210°F) between the values of 2.0 and 75.0 x 10^{-6} m^2/sec (centistokes). Equations are provided for calculating basic values for oils having viscosities at 99°C (210°F) below 2.0 x 10^{-6} m^2/sec (centistokes) or above 0.00163 m^2/sec (350 sec.), Saybolt Universal at 99°C (210°F).

The viscosity index is an empirical number indicating the effect of change of temperatures on the viscosity of an oil. A low viscosity index signifies relatively large change of viscosity with temperature.

B.II Test Methods for Lubricating Greases

1. Apparent Viscosity of Lubricating Greases

Specification: Federal Test Method Standard No. 791a, Method 306.4
ASTM D-1092-62

This method describes a procedure for measuring, in poises, the apparent viscosity of lubricating greases in the temperature range of -54°C to 38°C (-65°F to 100°F). Measurements are limited to the range of 2.5 to 10,000 N-sec/m^2 (25 to 100,000 poises) at 10 reciprocal seconds, and 0.1 to 10 N-sec/m^2 (1 to 100 poises) at 15,000 reciprocal seconds.

A grease sample is forced through a capillary by means of a floating piston actuated by a hydraulic system. From a predetermined rate of flow and the force in the system, the apparent viscosity is calculated by means of Poiseuille's equation. The apparent viscosity is determined at 16 different shear rates by use of two pump speeds and eight sizes of capillaries. The results are expressed by a log plot of apparent viscosity versus shear rate.

Precision: The following data should be used for judging the acceptability of results. Results should be considered suspect if they differ by more than the following:

		Percent of Mean	
Sample	Temperature	Repeatability	Reproducibility
Smooth, NLGI 2 Deister oil	-54°C (-65°F)	7	12
Smooth, NLGI 2 SAE 20 oil	25°C (77°F)	6	19
Fibrous, NLGI 1 SAE 20 oil	25°C (77°F)	6	23
Viscous, NLGI 1 SAE 90 oil	25°C (77°F)	7	30

2. Penetration of Lubricating Grease

Specification: Federal Test Method Standard No. 791a, Method 311.6
ASTM D-217-60T

This method describes three test procedures for measuring the consistency of lubricating grease by penetration of a standard cone. This method includes procedures for the measurement of worked, unworked and block penetrations.

Penetrations, measured in tenths of a millimeter, are determined at 25°C (77°F) by releasing a standard cone assembly and allowing the cone to drop into the grease for 5 sec. Worked penetrations are determined immediately after working the sample for 60 strokes in a standard grease worker. Unworked penetrations are determined on the sample as received. Block penetrations are determined on a freshly prepared face of a cube cut from a block of grease with a standard cutter.

Precision: Two results should not be considered suspect unless they differ more than the following amounts:

	Worked	Unworked	Block
Penetration range (0.1 mm.)			
Original penetrometer cone	130-400	85-400	Under 85
Alternate penetrometer cone	130-475	85-475	Under 85
Repeatability	7 Units	9 Units	3 Units
Reproducibility	15 Units	18 Units	7 Units

3. Penetration of Lubricating Greases After Mechanical Working

Specification: Federal Test Method Standard No. 791a, Method 313.2

This method is used for determining the consistency of lubricating greases that have been subjected to severe mechanical working. The sample is placed in a grease working machine and worked for 100,000 double strokes at 60 double strokes per minute. A standard cone penetration test, as described in ASTM D-217-60T and Federal Standard Test 311.6, is made on the worked sample.

Penetration, measured in tenths of a millimeter, is determined at 25°C (77°F) by releasing a standard cone assembly and allowing the cone to drop into the grease for 5 sec.

4. Oil Separation from Lubricating Grease (Static Technique)

Specification: Federal Test Method Standard No. 791a, Method 321.2

This method is used for determining the tendency of the oil in lubricating grease to separate at elevated temperature.

A measured sample (10 g.) of the grease is placed in a nickel wire gauze cone (60 mesh) under static conditions for the time and temperature specified (usually 30 hr. at 100°C (212°F) and then determining the percentage by weight of the oil drained through the cone.

5. Oil Separation from Lubricating Grease During Storage (Air Pressure Technique)

Specification: Federal Test Method Standard No. 791a, Method 322.2
ASTM D-1742-60

This method describes a procedure for determining the tendency of lubricating grease to separate oil during storage in both conventional and cratered containers. This method is not suitable for use with greases softer than NLGI No. 1 consistency, because of a tendency for the grease to seep through the screen. It does not predict the stability of grease under dynamic conditions.

A sample of grease is placed on a No. 200 sieve and subjected to 1,723 N/m^2 (0.25 psi) air pressure for 24 hr. at 25°C (77°F). Any oil seepage which occurs drains into a beaker and is weighed. The results are reported as the percentage weight of the oil separated.

6. Performance Characteristics of Lubricating Greases in Antifriction Bearings at Elevated Temperatures

Specification: Federal Test Method Standard No. 791a, Method 331.1

This method is used for determining the lubricating ability of greases in antifriction bearings under axial and radial loads to withstand elevated temperatures.

A sample of test grease (3.0 g.) is packed in a No. 204K ball bearing; the bearing then mounted on the test spindle and installed in the test fixture with the specified radial 13.44 N (3 lb.) and thrust 22.40 N (5 lb.) bearing loads. The test fixture is installed in an oven at a specified temperature, and the spindle and bearing inner race are rotated at 10,000 rpm. The bearing is inspected for wear and grease leakage at 20 hr. intervals for a specified time or until failure. Failure is indicated by: increase in frictional torque sufficient to trip motor overload switch, locking of bearing and belt slippage at startup, and by excessive grease leakage indicated by grease on face of bearing housing.

7. Functional Life of Ball Bearing Grease

Specification: ASTM D-1741-60T

This method provides two procedures for evaluating the functional life of ball bearing greases when tested under prescribed laboratory conditions. It is not the equivalent of long time service tests and is limited to greases for operating temperatures up to 125°C (257°F).

Procedure A - Performance life, including leakage evaluation. Two No. 30BC03406 ball bearings are cleaned and packed with the sample grease and placed in the shaft of a special belt-driven grease tester equipped with a thermostat controlled heater. The grease tester end caps are filled with grease and the unit assembled. The tester is operated at 3,500 rpm and 125°C (257°F) for 20 hr. and then stopped for 4 hr. and the cycle repeated until lubricant failure occurs. This procedure simulated "in-the-field" grease-gun bearing lubrication.

Procedure B - Performance life alone. This is the same as Procedure A above except only one-third of the bearing ball space is packed with grease and no grease is packed in the housing. This procedure simulated "factory-packed" bearings applications.

Grease failure may be considered to occur by one of the following conditions; stalling of motor during operation, stalling of motor during restart after shutdown, temperature rise of 10°C (18°F) and by an increase in noise level lasting more than 10 min.

The results are reported as test conditions, type of failure, bearing inspection after test, and grease leaking.

8. Low Temperature Torque of Ball Bearing Greases

Specifications: Federal Test Method Standard No. 791a, Method
ASTM D-1478-63

This method determines the extent to which a low temperature grease retards the rotation of a slow speed ball bearing when subjected to subzero temperature. The method employs grease of extremely low torque characteristics at -54°C (-65°F) and may not be applicable to other greases, speeds, or temperatures.

A No. 204 ball bearing is packed completely full of the test grease and cleaned flush with the sides. The bearing remains stationary while its temperature is lowered to -54°C (-65°F) and held for 2 hr. At the end of this time, the inner ring of the bearing is rotated at 1 rpm and the retaining force on the outer ring is determined. The starting and running torques in grams-centimeters are computed and recorded.

Precision: Results should be considered suspect if they differ by more than the following amounts.

	Percent of Mean	
	Repeatability	Reproducibility
Starting torque	15.0	50
Running torque	35.0	73

9. Gear Wear

Specification: Federal Test Method Standard No. 791a, Method 335.1

This method describes a procedure for determining the relative lubricity of grease.

A set of special test gears of known wear properties, brass and steel, are lubricated with the test grease and mounted in the tester. The brass gear is driven by an oscillating drive mechanism and drives the steel gear which is torque loaded by suspended weight. After the test, the loss of weight of the brass gear is determined. The results are reported as the average loss of weight per 1,000 cycles.

10. Evaporation Loss of Lubricating Greases and Oils

Specification: Federal Test Method Standard No. 791a, Method 351.2, ASTM D-972-56

This method describes the test procedure for determining the evaporation loss of lubricating greases and oils for applications where evaporation loss is a factor. Evaporation loss data can be obtained at any temperature in the range of 99°C to 149°C (210°F to 300°F).

A measured sample is placed in a standard evaporation cell and the cell then placed in a bath maintained at the desired temperature. Heated air is passed through the cell at a standard rate for 22 hr. The evaporation loss is calculated from the weight loss of the sample.

Precision: Results should not differ from the mean by more than the following amounts:

Repeatability - 2.5% of mean
Reproducibility - 10% of mean.

11. Dropping Point of Lubricating Grease

Specification: Federal Test Method Standard No.791a, Method 1421.1, ASTM D-566-42

This method covers the procedure for the determination of the ASTM-IP dropping point of lubricating grease. The dropping point is that temperature at which the grease passes from a semisolid state to a liquid state under the conditions of test.

A reproducible sample of grease is placed in a specified standard cup which has a small calibrated orifice in the bottom. The cup is placed in a special test tube with a thermometer held in the grease by a rubber stopper in the test tube. The test tube assembly is placed in an oil bath and the bath is heated slowly in a prescribed manner. The temperature of the grease and the temperature of the oil bath are recorded when a drop of grease protrudes through the hole in the bottom of the standard cup and drops into the test tube. The average of the two temperatures is the dropping point.

Precision: A sufficient number of determinators shall be made so that an average deviation from the mean is 1.5°C (3°F), or less. The average results so obtained by different operators with different apparatus shall agree within 3°C (6°F).

12. Thermal Stability of Greases

Specification: Federal Test Method Standard No. 791a, Method 2503.1

This method is used for providing an indication of the thermal stability of a grease in the presence of steel. It consists of heating a "sandwich" of test grease and two steel plates in an oven at 100°C (212°F) for 7 days, then checking visually the grease for hardening, separation or any other changes except color.

13. Dirt Content of Grease

Specification: Federal Test Method Standard No. 791a, Method 3005.3

This method is used for determining the size and concentration of foreign particles in lubricating greases.

A known quantity of grease is applied to a microscope slide and the slide is examined under a microscope, with an eyepiece micrometer, to determine the size and number of particles present. Results are reported as the number of particles per cubic centimeter of grease, for three groups of particle size; 25-75 microns, 75-125 microns, and those over 125 microns.

14. Estimation of Deleterious Particles in Lubricating Grease

Specification: ASTM D-1404-56T

This method describes a procedure for the detection and estimation of deleterious particles in lubricating grease. A deleterious particle by this method is one which will scratch a polished plastic surface.

A small sample of the grease is placed between two clean, highly polished acrylate plastic plates held rigidly and parallel to each other in metal holders. The assembly is pressed together, squeezing the grease between the plates in a thin layer. Any particles larger than the distance of separation of the plates and harder than plastic will become imbedded in the plastic surfaces. One plate is rotated at 30 degrees with respect to the other, while the assembly is under pressure. The imbedded particles will then form characteristic arc-shaped scratches on one or both plates. The scratches are counted and the number reported.

15. Water Resistance of Lubricating Greases

Specification: Federal Test Method Standard No. 791a, Method 3252.3, ASTM D-1264-63

This method is intended to evaluate the resistance of a lubricating grease to washout by water from a bearing when tested at 38°C (100°F) and 79°C (175°F) under prescribed laboratory conditions, but is not considered the equivalent of service evaluation tests.

A measured sample of the grease is packed in a standard ball bearing, and the bearing accurately weighed and inserted in a housing with specified clearances and rotated at 600 ± 30 rpm. At the specified test temperature, water impinges on the bearing housing at a rate of 5 ± 0.5 ml/sec. The amount of grease washed out in 1 hr., as determined by weight change, is a measure of the resistance of the grease to water washout.

Precision:

Reproducibility: Results should not differ by more than ± 10% grease washout.

16. Oxidation Stability of Lubricating Greases (Oxygen Bomb)

Specification: Federal Test Method Standard No. 791a, Method 3453.1, ASTM D-942-50, Institute of Petroleum, IP 142/64

This method describes the test for determining the resistance of lubricating greases to oxidation when stored under static conditions for long periods of time, as, for instance, thin coatings on antifriction bearings and on motor parts, etc.

Samples of the grease are placed in a standard oxygen bomb and the bomb is heated to 99°C (210°F) and filled with oxygen at 7.58×10^5 N/m^2 (110 psi). The degree of oxidation after a given period of time is determined by the corresponding decrease in oxygen pressure. Specifications are usually given in terms of pressure drop in psi or N/m^2 at one or more time intervals, for instance after 100 hr., 200 hr., etc.

Precision: Results should not differ from the mean by more than the following amounts.

Pressure Drop SI N/m^2	Pressure Drop (English) (psi)	Repeatability SI N/m^2	Repeatability (English) (psi)	Reproducibility SI N/m^2	Reproducibility (English) (psi)
0 - 3.48×10^4	(0 -5)	6,895	(1)	20,685	(3)
3.48×10^4 - 6.89×10^4	(5 - 10)	13,790	(2)	27,580	(4)
6.89×10^4 - 13.79×10^4	(10 - 20)	20,685	(3)	41,370	(6)
13.79×10^4 - 37.9×10^4	(20 - 55)	34,475	(5)	68,950	(10)

17. Channeling Characteristics

Specification: Federal Test Method Standard No. 791a, Method 3456

This method is used for determining the channeling characteristics of lubricants at low temperature.

A 650 ml. sample is placed in a round container and cooled to the specified temperature for $\pm$ 18 hr. A channel is then cut through the sample and observations made to determine if the sample flows back to completely cover the bottom of the container in 10 sec. If it has, it is reported as nonchanneling; if not, it is reported as channeling.

18. Rust Preventive Properties of Lubricating Greases

Specifications: Federal Test Method Standard No. 791a, Method 4012, ASTM D-1743-60T

This method describes a test for determining the corrosion preventive properties of greases, using grease lubricated tapered roller bearings stored under wet conditions.

Clean new bearings are lubricated, then run under a light thrust load for 60 sec. so as to distribute the lubricant in a pattern that might be found in service. The bearings are then stored for 2 weeks at 25°C (77°F) and 100% relative humidity. After cleaning,the bearings are inspected for evidence of corrosion. Results are reported as ratings of 1, 2, or 3, with 1 being no observable corrosion.

Precision: Repeatability may be judged by the fact that 99% of results obtained by 20 labs, with 10 samples, were in agreement. Reproducibility may be judged by the fact that the 20 labs matched the concensus at least 84% of the time on the seven samples with good or bad protection, but only 44% of the time on the three samples with marginal protections.

19. Corrosiveness of Greases (Copper Strip 100°C (212°F))

Specification: Federal Test Method Standard No. 791a, Method 5309.3

This method is used to determine the corrosive properties of grease at elevated temperatures.

A prepared copper strip is partially immersed in a sample of the grease at 100°C (212°F) for 24 hr. and then the strip and the sample of grease are visually inspected for any change in color of specimen or other evidence of corrosion. The strip is further examined under a microscope of approximately 60 diameter magnification and any corrosion described. Any green color in the grease is also reported.

20. Rust Protection by Metal Preservatives in the Humidity Cabinet

Specification: Federal Test Method Standard No. 791a, Method 5310.1 ASTM D-1748-62T

This method is used for evaluating the rust preventative properties of method preservatives under conditions of high humidity.

Cold rolled steel test panels (SAE 1010, 2 x 4 x 1/8 in.) are prepared to a prescribed surface finish, dipped in the test preventative, allowed to drain, and then suspended in a humidity cabinet at 49°C (120°F) for a specified number of hours. The preventative oil fails or passes the test according to the size and number of rust dots on the test surface of the panels as follows:

Pass - not more than three dots of rust, none larger than 1.0 mm. in diameter.
Fail - four or more rust dots, or one larger than 1.0 mm. in diameter.

21. Corrosiveness of Greases (Oxygen Bomb Copper Strip)

Specification: Federal Test Method Standard No. 791a, Method 5314.1, ASTM D-1261-55

This method describes the test for determining the effect of grease on copper parts of bearing assemblies with which the grease comes in contact. Although test procedure is not intended as a stability test of grease, some indication of the stability of greases in storage in contact with copper may be found by visual inspection of the grease at the end of the test.

A prepared copper strip is partially immersed in a sample of grease and heated to 99°C (210°F) in a bomb filled with oxygen at 7.58×10^5 N/m^2 (110 psi) for 20 hr. The copper strip is removed, washed, and examined for evidence of discoloration, etching and corrosion. The examination is made by comparison with reference strips mutually approved by purchaser and seller.

22. Cycling Performance Test of Grease

Specification: Federal Test Method Standard No. 791a, Method 5413

This method is used for providing an indication of the suitability of a grease for use in pneumatic systems between rubber and metal parts.

Three O-rings are placed in a standard piston and cylinder cycling system and lubricated with a sample of the grease. The assembled piston is then stored at 14°C (58°F) for 14 days to "age" the grease. The aged piston and cylinder are then connected to a cycling ring under pneumatic pressure of $9.65 - 11.01 \times 10^6$ N/m^2 (1,400-1,600 psi) and cycled at 36 cpm for 50,000 cycles with a 1.397×10^{-1}m. (5-1/2 in.) stroke, cylinder temperature controlled at 52°C (125°F). The setup is then disassembled and bearing surfaces, O-rings and lubricant are examined.

23. Resistance of Grease to Fuel

Specification: Federal Test Method Standard No. 791a, Method 5414.2

This method is used for determining the resistance of grease to the solvent action of fuel. It consists of determining the solubility of the grease in a standard test fluid (1/2 hr. shaker cycle with MIL-S-3136, Type II fluid), and observing the physical changes caused by an 8-hr. immersion in the test fluid 25°C (77°F). The solubility is reported as percent weight loss of the grease specimen.

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